



Behavioural Observations of White Rhinos at Ziwa Rhino Sanctuary

**analyses from data collection between
June 2010 and April 2021**

**a Rhino Fund Uganda technical report
may 2021**

Introduction

Since June 2010 when a standardised data capture system was introduced for rhino monitoring rangers, many aspects of rhino behaviour at Ziwa Rhino Sanctuary have been published in *Pachyderm* and elsewhere.

This report updates the information contained in these papers where new and more data has become available and is brought together in one document. It will serve as a modern guide to wild white rhino behaviour as a complement to the seminal work of Norman Owen-Smith (1973) from which most white rhino ecology has previously been gleaned.

The data obtained through the 24-hour per day monitoring, with data captured on an hourly basis and notes on a minute by minute basis, is unique, extensive and robust.

With a founder group of only six rhinos, some behaviours may be considered “out of the ordinary” given such a low-density population. However, observations on the changes in behaviour as the population increases and a social organisation develops is valuable to rhino managers.

This is not an academic report and only some data has been statistically analysed. It is a statement of what has been learned in practice and a guide for rhino managers.

The report could not have been prepared without the ZRS rangers collecting the information diligently throughout the day and night never minding the weather, without data capturer Henry entering it on computer, without Dr Petra Campbell, RFU IT and Data Analysis Adviser, designing analysis systems.



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An Overview of white rhino behaviour at Ziwa Rhino Sanctuary

ACTIVITY SCHEDULE

Activity Schedule - Proportion of time spent on main activities:

Feeding 61% = 14.6 hrs/day Resting 37.5% = 9.0 hrs/day Moving 1.5% = 0.4 hrs/day

Main feeding times: 7am to 10am, 4pm to 9pm Main resting times: 1am to 6am, 11am to 3pm

Water mostly taken between 3pm and 5pm

Fighting was mainly between adult males over breeding rights and significantly reduced by dehorning.

REPRODUCTION

The level of association between a male and a female ready for mating increases markedly prior to conception and drops off rapidly thereafter. The association can start as much as three months or as little as a few days before conception.

A continuous consort period leading up to copulation averaged 11 days but continued after copulation for only 33 hours on average.

Copulations occurred mostly once in a day but up to four times in one day, lasting on average 17 minutes

Mean of 26 gestation periods corrected 493 SD9 range 484-502

SD = standard deviation

The average age of females at first mating was 3 years 10 months with the age at first calving more likely to be 5 to 5.5 years.

The mean gestation period was estimated at 493 days range 473 - 508

There was no particular month or time of day for a birth.

The sign of an imminent birth was when the female chased her current calf away which averaged six hours and eight minutes prior to the new birth.

Once suckling had started, it occurred on average, three times a day

Females accepted their first mating on average 189 days (approximately 6 months) after the birth of the new calf.

SOCIAL ORGANISATION

With a founder population of only six rhinos, a stable social organisation developed slowly. The three males were solitary. The three females, after the birth of their first calves, maintained independent areas. From second and subsequent calvings, the former calf was chased away and sometimes formed associations with other females with their calves but mainly with other sub-adults in any combination of males and females.

The longest sub-adult association between two males lasted 63 months.

At the end of 2020, three males had established territories and the two subordinate males were keeping out of their way. Nine breeding females had established home ranges; two sub-adults had remained with their mothers while 10 other sub-adults had joined forces, moving together.

Current Social Organisation – end April 2021

| | | | |
|---------------------------|---|-----------------------------------|---------------------------------------|
| Solitary Males | Taleo Moja Hassani Augustu Obama | | |
| Female + calf | Bella and Jabali Luna and Kuc | Laloyo and Rhoda Uhuru and Rae | Malaika and Pipo Waribe and Anywar |
| Female + calf + sub-adult | Kori and Whittaker + Europe | | Donna and Seiji + Ajabu |
| Sub-adults group of 10 | Sonic + Nguzo + Zawadi + Noelle + Madam + Apache + Kageri + Nakitoma + Armijn + Elias | | |

Deaths

There have been three rhino deaths between 2010 and the end of April 2021:

Justus, a sub-adult male, died on 12/04/2015, following injuries sustained while running away from a fight with Taleo

Nandi, a founder female, died on 28/02/2021, following a long illness and despite treatment. The cause of the illness is unclear and still being investigated.

Achiru, born on 9/1/2021, female calf of Nandi, could not be looked after by her sick mother so was transferred to UWEC for the difficult process of hand rearing but unfortunately did not survive.

USE OF SPACE

Of the fifteen sector/blocks, six represent some 80% use of space by the rhinos with sectors M and K and blocks R1 and W3 rarely used.

Three male territories 66% core areas covered 18.1, 10.6 and 8.4 sq kms with the two sub-ordinate males home ranges 19.8 and 18.3 sq km

The nine breeding female home ranges covered 3.0, 4.7, 4.1, 1.2, 1.5, 1.8, 1.9, 1.5 and 1.1 sq kms.

The average maximum distance a rhino moved across its territory or home range over the analysis period was 8.1 kms for males, 10.8 kms for sub-ordinate males, 11.5 kms for older breeding females, 8.2 kms for younger breeding females. The sub-adult group of ten individuals covered 6.0 kms.

FOOD RESOURCE

White rhinos prefer to eat short grass. Bush encroachment and tall grass has been managed for better access by the rhinos using burning, cattle grazing and manual labour.

Comprehensive sampling of grazed areas indicated 17 preferred species and 15 avoided.

In the non-grazed areas 16 preferred species and 11 avoided species were present. This suggests that further improvement measures would open up new areas for the rhinos although water availability could be limiting so new water points would be required.

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SECTION A Background

A.1. Uganda Rhinos – Brief History

Many years ago there were probably hundreds of rhinos in Uganda but during the 1970's and 1980's, especially during the time of Idi Amin, the rhinos were heavily poached so that in 1983 the last remaining rhino in Uganda was killed.

In 1997 it was agreed that the civil unrest was over and the government was stable so the time was right to bring rhinos back to Uganda. Rhino Fund Uganda, a non-governmental organisation, was formed to raise money to help make this happen.

In 2001, two rhinos were brought in from Solio Ranch in Kenya to Entebbe Zoo, now called the Uganda Wildlife Education Centre, to educate and raise awareness among Ugandans and visitors about the plight of the rhino and the need to bring them back to Uganda.

Rhino Fund continued to raise money such that by 2004, they had sufficient funds to start a sanctuary. Ziwa was identified as excellent habitat for white rhinos. Formerly a cattle area, the money was used to build the electric fence and put in the relevant infrastructure.

In 2005, four rhinos were brought from Solio Ranch in Kenya, two males and two females and these were joined a year later by two rhinos, a male and a female, which were donated by Disney Animal Kingdom in America. These six rhinos settled well in their new home and started to breed.

In June 2009, twenty-six years after the death of the last rhino in Uganda, a calf was born. The father Taleo was from Kenya and the mother Nandi was from the USA. The male calf was named Obama.

The goal is to breed many more rhinos and when there are around 50, move 15 to 20 into a second sanctuary to maintain the breeding performance at the fastest rate.

A.2. Introduction

Ziwa Rhino Sanctuary (ZRS) covers 64.2 sq kms in the Nagasongola district of central Uganda. Prior to becoming a wildlife sanctuary in 2004, the area was part of a cattle farming operation. As such there is little other wildlife on the Sanctuary apart from a small number of small antelopes and vervet monkeys which do not offer any danger to humans.

Ziwa is almost unique for a rhino sanctuary, as it has no predators such as lions or dangerous wildlife such as elephants and buffaloes, so the rangers are able to follow the rhinos, even throughout the hours of darkness.

The sanctuary area is divided between raised areas, ridges or interfluves with alluvial sandy soils and shallow drainage lines with clay loams or 'black cotton'. The soils of the area are classified as Ferralsols and Fluvisols.

The dominant vegetation types are *Combretum* woodland mosaic, wooded grassland, open and swamp grassland, and riverine swamp along the Lugogo River. There are only small areas of dense bushland or thicket. Approximately 30% of the area becomes seasonally inundated or waterlogged, including much of the grassland on the drainage lines and adjoining the swamp. Average annual rainfall between 2004 and 2012 was 1,046 mm (range 708–1,345 mm).

The map (Figure A.1) below shows how the 64.2 sq km area of the sanctuary has been fenced and how the internal area has been sub-divided into sectors and blocks for reporting purposes.

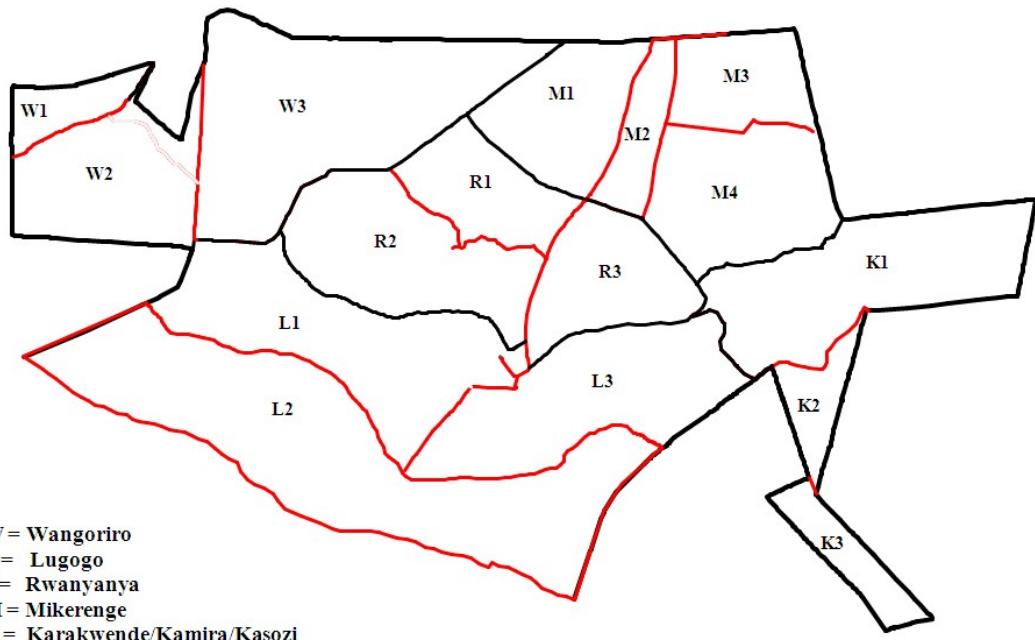


Figure A.1 Map of Ziwa Rhino Sanctuary showing sectors and blocks used for monitoring

A.3. Security and Monitoring

The rhinos are held under heavy 24-hour-a-day security by armed guards from the Uganda Wildlife Authority and Rhino Fund Uganda monitoring rangers. The rangers monitoring each of the rhino family groups follow the animals on foot from a distance but keeping them in sight as much as possible.

During the hours of darkness, rangers have torches, which they use to observe the rhinos whenever they hear any sound of activity, and at least at 15-minute intervals to check on the rhinos. During full moon periods the rhinos are easily observed without the need for torches.

Since June 2010, to better understand the behaviour and movements of the rhinos the monitors have kept an hourly record of the location, key activities of each rhino and their associations with conspecifics. The rangers completed a daily sighting form for each hour of the 24 hours of each day of each of the months.

For each rhino the rangers recorded the location—sector and block; type of habitat—wet swamp, dry swamp or other; one of three main activities—feeding, resting, moving; plus any of four secondary activities—drinking, wallowing, mating or fighting—that might also have occurred during each hour. All other rhinos found in close proximity (within 10 m) were recorded as an association.

Data is entered using Microsoft Excel and macros have been written to automate the consolidation and analysis of the data. For location and habitat type, the analysis was based on the number of rhinos found in each location and habitat type for each hour of the day; for activities the analysis was based on the number of hours spent on the activity per day.

The data is not always complete as there were occasions when the particular rhino was out of sight especially in thick bush habitat. The causes of this are varied but include being frightened by lightening or the unwelcome physical attention of a male.

At the end of the reporting period for this report there were thirty-three rhinos in the sanctuary

SECTION B The main ways that the rhinos spend their days

Table B.1 shows the level of the main activities for each hour of a 24-hour day as a percentage (mean of eight years) of the total spent (100%) on each activity in the day. The data from the table suggest a 'typical' day presented as a 24-hour clock in figure B.1.

Table B.1 Main activities of the Ziwa RS white rhinos at each hour of the day as a percentage of total hours spent for each activity

| time | moving | resting | feeding | drinking |
|-----------|----------|----------|---------|-----------|
| 0100-0200 | 5 | 6 | 2 | 1 |
| 0200-0300 | 6 | 6 | 2 | 1 |
| 0300-0400 | 6 | 7 | 2 | 1 |
| 0400-0500 | 5 | 8 | 2 | 0 |
| 0500-0600 | 4 | 8 | 3 | 1 |
| 0600-0700 | 4 | 4 | 4 | 1 |
| 0700-0800 | 2 | 0 | 7 | 1 |
| 0800-0900 | 3 | 0 | 7 | 2 |
| 0900-1000 | 4 | 1 | 6 | 4 |
| 1000-1100 | 4 | 3 | 5 | 4 |
| 1100-1200 | 3 | 8 | 2 | 2 |
| 1200-1300 | 2 | 9 | 1 | 2 |
| 1300-1400 | 3 | 8 | 1 | 2 |
| 1400-1500 | 3 | 6 | 2 | 6 |
| 1500-1600 | 5 | 3 | 4 | 12 |
| 1600-1700 | 6 | 1 | 6 | 20 |
| 1700-1800 | 3 | 0 | 7 | 15 |
| 1800-1900 | 3 | 0 | 7 | 7 |
| 1900-2000 | 4 | 0 | 7 | 7 |
| 2000-2100 | 5 | 1 | 7 | 5 |
| 2100-2200 | 5 | 2 | 6 | 3 |
| 2200-2300 | 5 | 4 | 5 | 2 |
| 2300-2400 | 5 | 6 | 4 | 1 |
| 2400-0100 | 5 | 7 | 3 | 1 |
| mean | 4 | 4 | 4 | 4 |

Note: significant figures are shown: negative in italics: positive in bold

The time spent by the ZRS white rhinos on each of the three main activities as a percentage of the total time for each year of the study period is shown in table B.2

Table B.2 Percentage time spent on each main activity of the white rhinos at Ziwa RS for the years 2011-2018

| year | moving | resting | feeding |
|-----------|--------|---------|---------|
| 2019 | 1 | 38 | 61 |
| 2018 | 1 | 38 | 61 |
| 2017 | 1 | 39 | 60 |
| 2016 | 1 | 38 | 61 |
| 2015 | 1 | 39 | 60 |
| 2014 | 1 | 37 | 62 |
| 2013 | 2 | 38 | 60 |
| 2012 | 3 | 37 | 60 |
| 2011 | 2 | 36 | 62 |
| mean | 1 | 38 | 61 |
| SD | 1 | 1 | 1 |
| range | 1-3 | 36-39 | 60-62 |
| hrs/24hrs | 0.4 | 9.0 | 14.6 |

The mean proportion of time spent on the main activities - feeding 61%, resting 38% and moving 1% - from the ranges of the nine years of data show a high degree of consistency between years.

The mean percentages of each activity applied to a period of 24 hours suggests a white rhino feeds for 14.6 hours a day, rests for 9.0 hours a day and moves for 0.4 hours. However, the rhinos often move while feeding especially after their main period of rest when they actively move to water for drinking and wallowing. The monitoring rangers would record the main activity as feeding and not moving. This can be seen in table 1 where there is data for moving in all the hourly periods though at a low level.

B.1. Overview of Main Activities

The "suggested clock" in Figure B.1 shows the main periods for feeding were 7am to 10am and 4pm to 9pm; the main period for resting was between 5am to 6am and 11am to 3pm. The remaining periods show no preference for a particular main activity. Water was taken mostly between 3pm and 6pm.

The data collected, and as presented in this section, is the most comprehensive published for a full 24 hours of white rhino activity in the wild, especially the activity of rhinos at night.

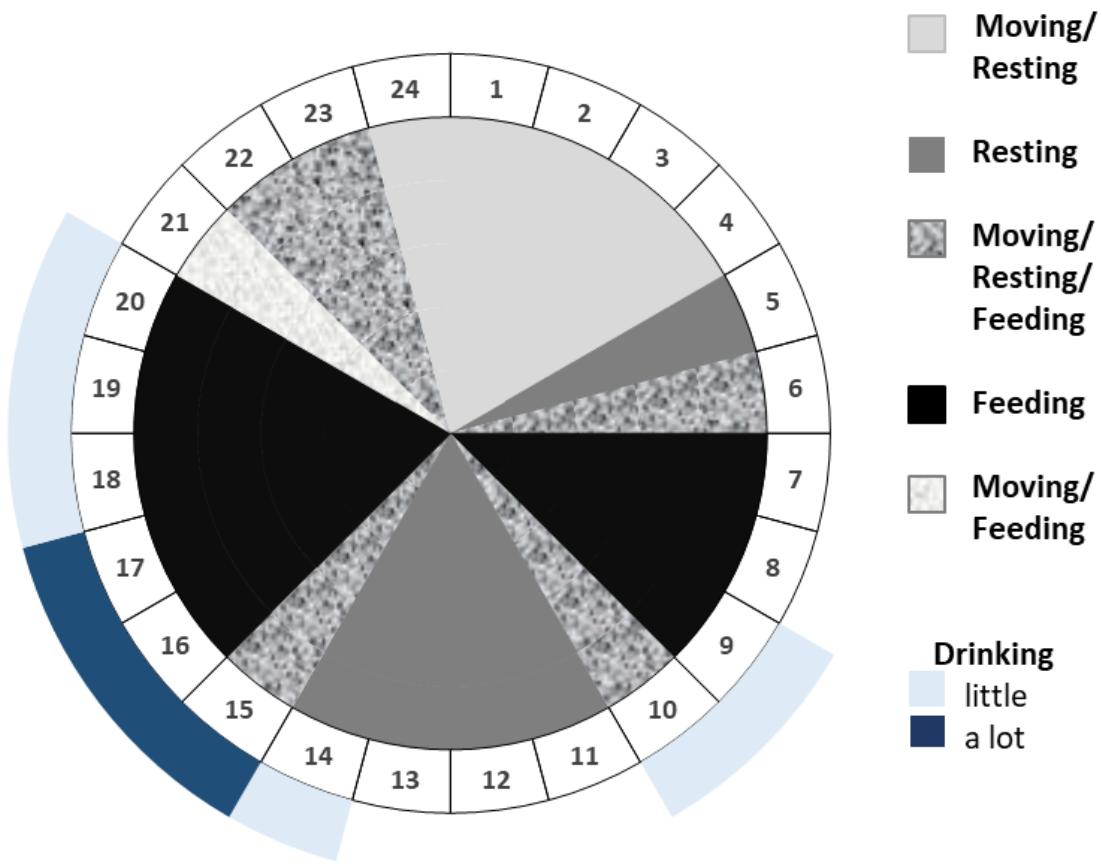


Figure B.1 Diagram of the 'suggested' 24 hour clock of the main activities of the white rhinos at Ziwa RS

B.2. Secondary Activities

Rangers record a number of secondary activities – fighting and mating – and more latterly wallowing and suckling. Mating and suckling data is reported later under the section Reproduction while wallowing data is incomplete so is not reported.

B.2.1 Fighting

Adult male white rhinos compete for breeding rights and they may also fight with immature males to establish dominance. In ZRS, a mature and dominant male, Taleo, regularly fought with the three immature males, one of which, Justus, was fatally injured. It was decided that, in order to minimise the frequency of fighting and the likelihood of serious injuries, Taleo and two other adult males, Moja and Hassani, should be de-horned. Since the horns of the males would take at least two years to grow to a significant size, it would allow time for the remaining immature males to become strong enough to defend themselves.

Table B.2.1 shows a summary of the fighting data obtained from the available sightings. Initially, Taleo exhibited dominance over its nearest male rival Moja and was the only breeding male thereby fathering the first nine calves to be born in the sanctuary (confirmed by DNA analysis).

Table B.2.1. Fighting occurrences 2011-2017.

| Results | Taleo | Moja | Hassani |
|--------------|------------|-----------|-----------|
| Taleo | x | 70 | 63 |
| Moja | 70 | x | 5 |
| Hassani | 63 | 5 | x |
| Young Males | 17 | 5 | 8 |
| TOTAL | 150 | 80 | 76 |

Fighting between these two males, became so serious in 2011 (Table B.2) that ZRS managers decided to de-horn Taleo. However, permission to de-horn was not granted. Moja responded to the renewed threat by moving to areas where Taleo did not visit thereby diminishing fighting frequency.

Table B.2. Breeding Male Fighting in Ziwa Rhino Reserve by Year.

| | TALEO | TALEO | MOJA |
|------|-------|---------|---------|
| | Moja | Augustu | Augustu |
| 2011 | 35 | n/a | n/a |
| 2012 | 1 | n/a | n/a |
| 2013 | 26 | n/a | n/a |
| 2014 | 5 | n/a | n/a |
| 2015 | 2 | n/a | n/a |
| 2016 | 1 | n/a | n/a |
| 2017 | 0 | n/a | n/a |
| 2018 | 0 | n/a | n/a |
| 2019 | 0 | 0 | 1 |
| 2020 | 2 | 15 | 13 |

In February 2013, Moja became stuck in mud at a dam that was drying out. It took a struggle of 17 hours before he was rescued. On recovery, the behaviour of Moja changed from being passive to becoming assertive. This led to renewed fighting with Taleo but, this time, Moja was dominant resulting in Taleo yielding to Moja and characterised by a marked reduction in their fighting thereafter (see Table 2). He also took over breeding rights with the mating data showing that he is the father of six of the seven calves born between 2015 and 2017.

Taleo maintained his aggressive nature by fighting with the younger male Hassani and the three immature males. In a fight in April 2015 the immature male Justus suffered a fractured knee and died from unknown causes despite veterinary intervention. The following month all three males—Taleo, Moja and Hassani—were de-horned in order to enable the immature males to develop unchallenged.

The main aim for de-horning aggressive/dominant males was to reduce fights between the adult males and young males. This was achieved with a 69% reduction in the frequency of such fights, namely between Taleo/ Moja/Hassani v Obama/Augustu (Tables B.2.3a and B.2.3b).

There was a 68% reduction in fighting between all males after de-horning. Fights involving Taleo reduced 72%, those involving Moja reduced 91% and Hassani 57%; fights between Taleo and Moja reduced by 88%.

Table B.2.3a. Aggression occurrences 2 years before dehorning.

| Results | Taleo | Moja | Hassani |
|-------------|-------|------|---------|
| Taleo | x | 17 | 27 |
| Moja | 17 | x | 2 |
| Hassani | 27 | 2 | x |
| Young Males | 10 | 3 | 1 |
| TOTAL | 54 | 22 | 30 |

Table B.2.3b. Aggression occurrences 2 years after dehorning.

| Results | Taleo | Moja | Hassani |
|-------------|-------|------|---------|
| Taleo | x | 2 | 9 |
| Moja | 2 | x | 0 |
| Hassani | 9 | 0 | x |
| Young Males | 4 | 0 | 4 |
| TOTAL | 15 | 2 | 13 |

Moja and Taleo kept apart from each other forming exclusive territories (see section E. Use of Space) with no fights between the two recorded from 2018 onwards. Hassani, who shares the same area as Taleo but acts as a subordinate, had one fight with young male Obama. It was also in a fight with two sub-adult males who strayed into Hassani when on an excursion out of their normal home range.

Fighting since the start of 2018 has largely involved the young male Augustu who, from March 2018, started to show the aggressive behavior of a breeding male. The two young males Augustu and Obama who has been in permanent association for 63 months had a serious fight lasting 25 minutes on 25/03/2018 which resulted in both having eye injuries. Obama tried to keep away from Augustu but on a further four occasions they fought. In July, both Obama and Augustu were dehorned to prevent causing further injuries to each other or any of the other rhinos.

From May 2018, Augustu was reported to have mated with four breeding females. Apart from fights with Obama, Augustu fought three times with the territorial male Moja, five times with adult females and twice with sub-adult females – all breeding related behaviour. Moja had six fights with adult females while attempting to mate and four fights with sub-adults in order to demonstrate dominance.

Table B2.4 Type of fights 2019 to end March 2021

| | 2019 | 2020 | 2021* |
|----------------------------------|-----------|-----------|-----------|
| Female v Breeding Male | 13 | 8 | 1 |
| Female v Subordinate Male | 2 | 6 | 0 |
| Breeding Male v Breeding Male | 2 | 30 | 6 |
| Breeding Male v Subordinate Male | 2 | 8 | 5 |
| Breeding Male v Sub-adult | 0 | 15 | 0 |
| ALL | 19 | 20 | 12 |

*Jan to end March only

Fighting between breeding males predominantly involved younger Augustu against older Taleo or Moja.

There were no instances of adult females fighting with each other or sub-adults fighting among themselves. Fighting was always in some way related to breeding rights.

SECTION C Reproduction

C.1. Introduction

Ziwa Rhino Sanctuary (ZRS) holds the only wild rhinos in Uganda. At the end of the reporting period there were 33 individuals including eight breeding females and three breeding males (see table 1).

Table C.1. Ziwa Rhino Sanctuary white rhino breeding individuals at the end of April 2021

| | | | | | | |
|-----------------------|-------|--------|---------|---------|--------|-------|
| Multi-calving females | Kori | Bella | Donna | Malaika | Laloyo | Uhuru |
| First calved females | Luna | Waribe | | | | |
| Due Ist calf female | Madam | | | | | |
| Breeding Males | Taleo | Moja | Augustu | | | |



C.2. Mating Activity

C.2.1 Male Associations and Reproduction

In this analysis, an association was measured by the number of hours in a month when a breeding male was with a female. The two main times when a male would be likely to associate with a female were considered to be when a female was receptive to mating and at the birth of the resulting calf.

Figures 1a to 1i show how often the two breeding males, Taleo and Moja, were found with each of the six breeding females with the estimated dates of conception (495 days before birth date) and the date of calf birth highlighted.

The data consistently shows that the level of association between a male and a female ready for mating increases markedly prior to conception and drops off rapidly afterwards. At and around the time of birth of the resulting calf, the breeding male shows little interest in being present.

This data shown has not been updated as the actions are continuous and normal behavioural features.

Fig 1a

Bella Together & Close with Males

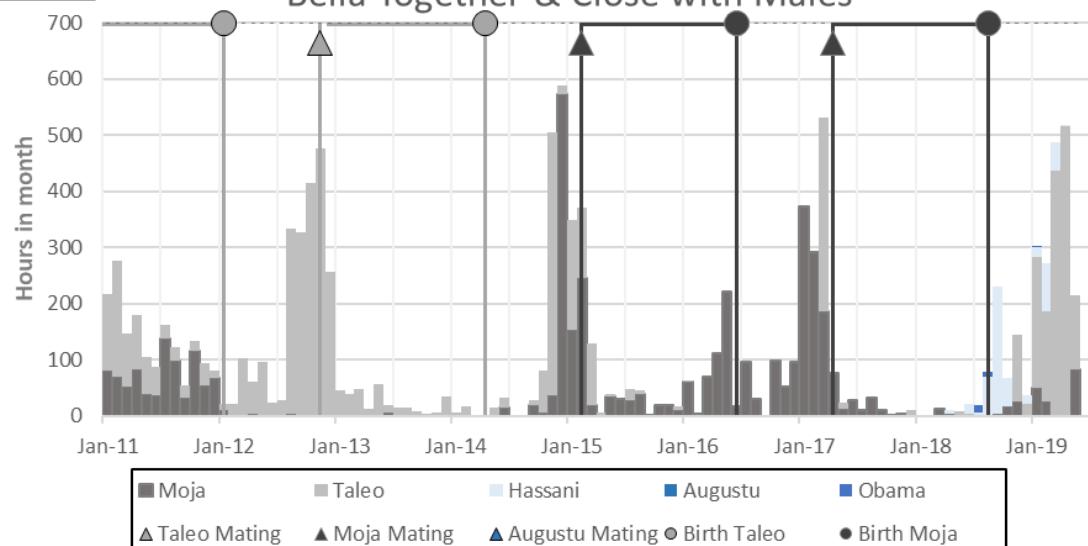


Fig 1b

Nandi Together & Close with Males

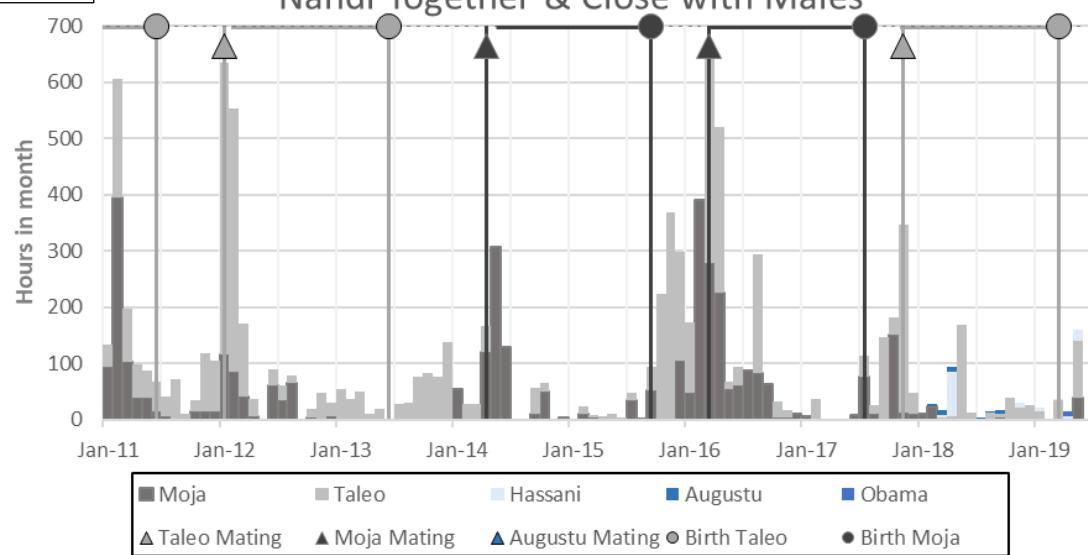


Fig 1c

Kori Together & Close with Males

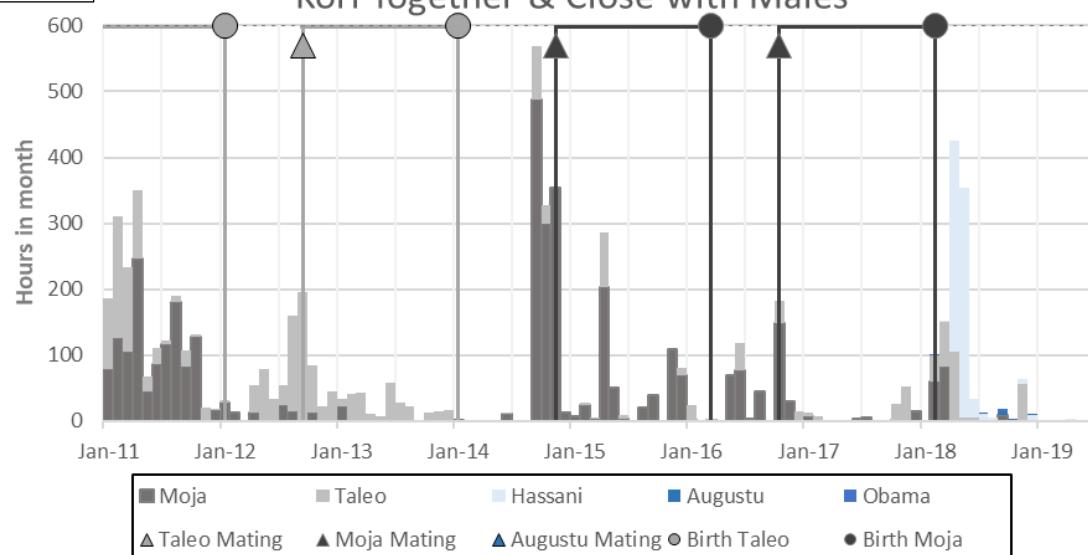


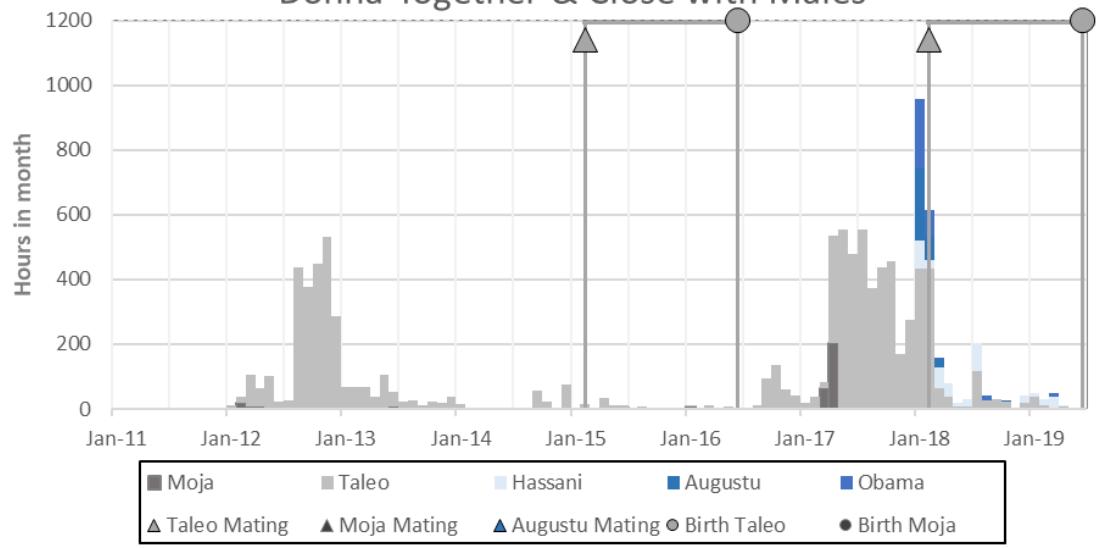
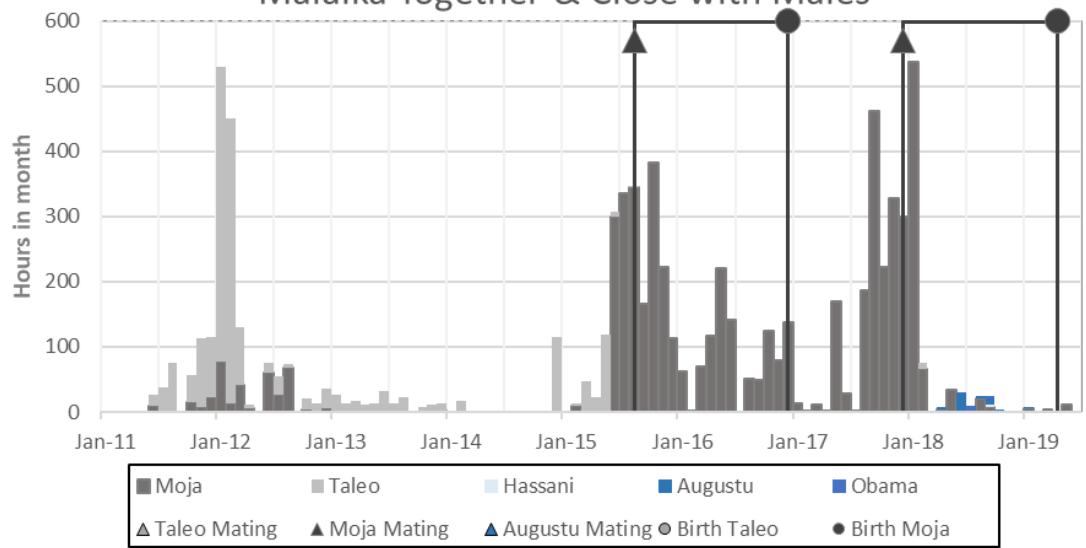
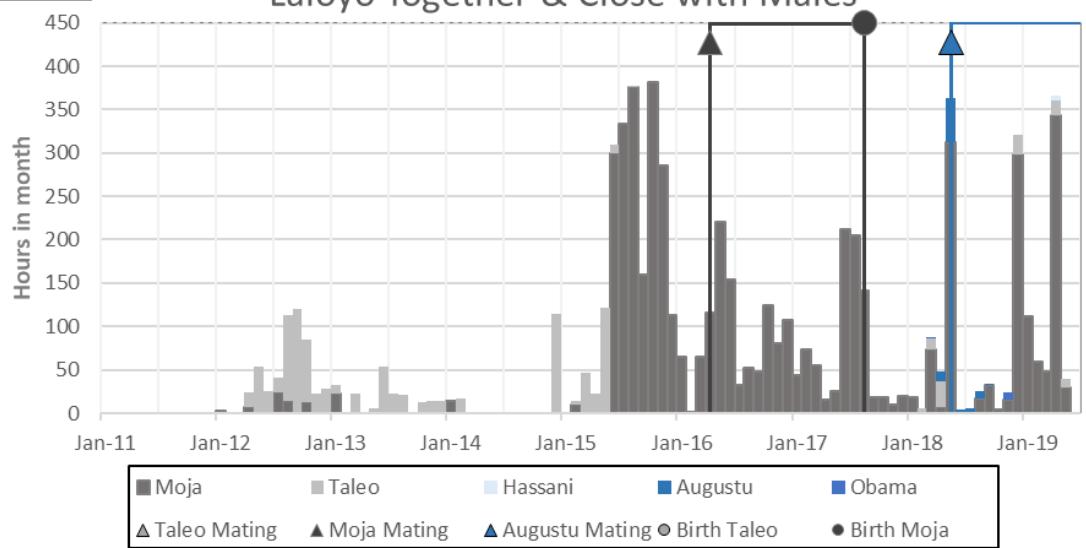
Fig 1d**Donna Together & Close with Males****Fig 1e****Malaika Together & Close with Males****Fig 1f****Laloyo Together & Close with Males**

Fig 1g

Uhuru Together & Close with Males

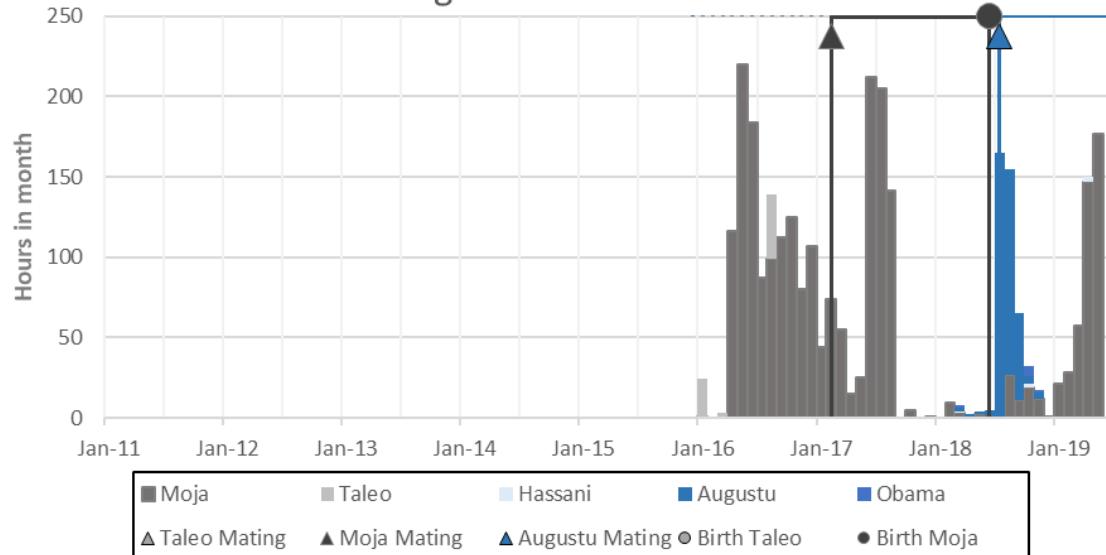


Fig 1h

Luna Together & Close with Males

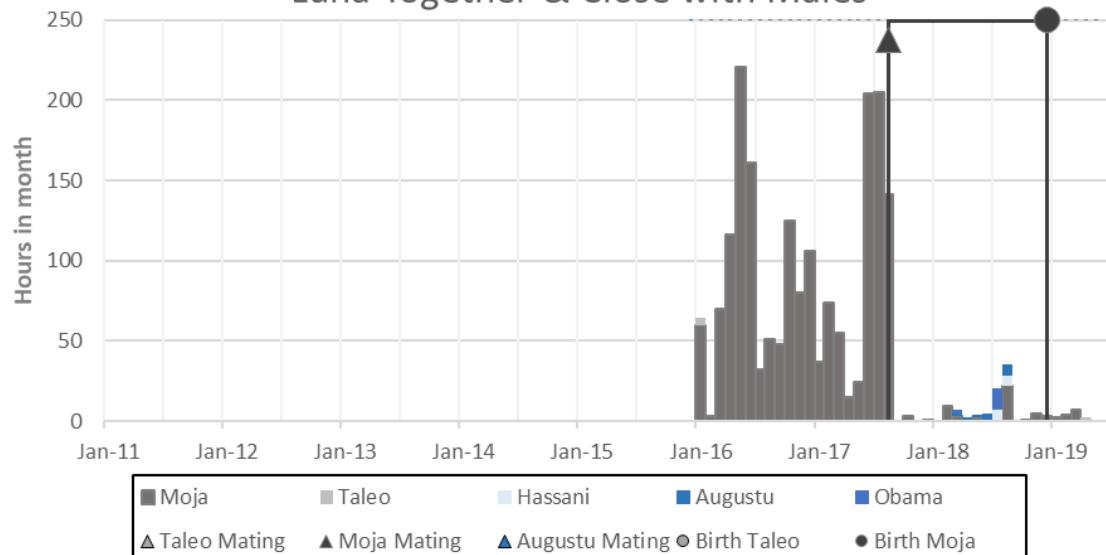
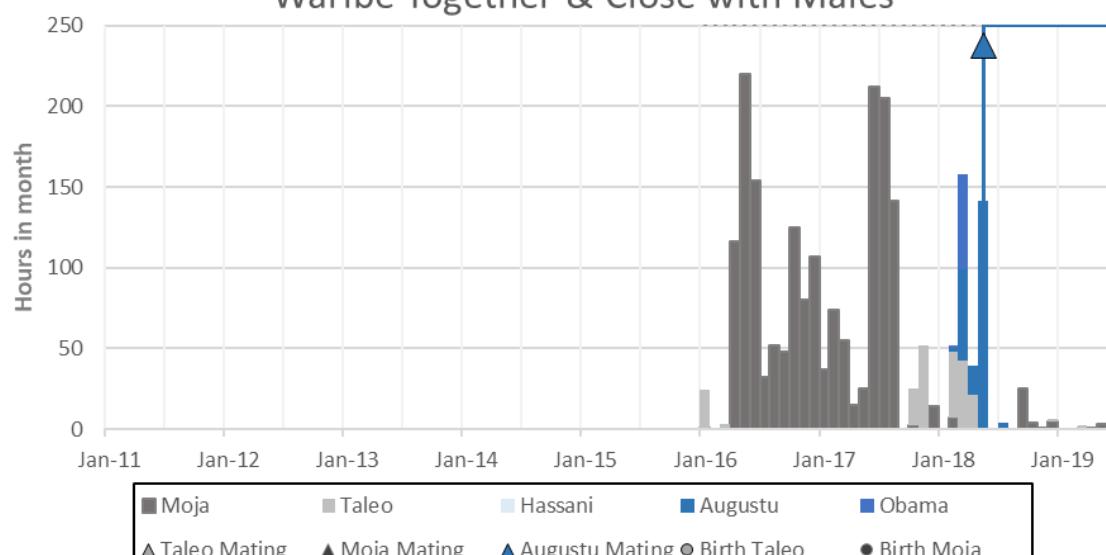


Fig 1i

Waribe Together & Close with Males



C.2.2 Consort Relationship

Table C.2.1 shows the association of a breeding male with a breeding female before, during and after the month of copulation mating, in hours per month. It can be seen that a consort relationship may start up to three months before the month of mating but is not on a continuous basis. On the other hand, a consort relationship may start only in the month of mating and may also finish in that month especially with younger breeding females.

Where a continuous consort period leading up to copulation was recorded, on average it lasted for 11 days, (range 2 – 32, n = 13) and continued, on average, for only 33 hours (range 3 – 190, n = 13).

Table C.2.1. The association of a breeding male with a breeding female before, during and after the month of copulation mating, in hours per month

| FEMALE | MONTH -3 | MONTH -2 | MONTH -1 | MONTH OF MATING | MONTH +1 |
|---------|-------------|-------------|-------------|--------------------|-------------|
| BELLA | 330 | 327 | 414 | 477 | 256 |
| | | 574 | 153 | 245 | |
| | 374 | 291 | 187 | 77 | |
| | 233 | 162 | 434 | 516 | 131 |
| KORI | | | 145 | 196 | |
| | | 487 | 299 | 353 | |
| | | | | 149 | |
| | | | 69 | 105 | |
| NANDI | | | 521 | 468 | 129 |
| | | | | 120 | 307 |
| | | | 391 | 279 | 225 |
| | | | | 335 | |
| MALAIKA | | 300 | 335 | 343 | 162 |
| | | | | 538 | |
| DONNA | 171 | 274 | 435 | 433 | |
| LALOYO | | | | 116 | |
| | | | | 313 | 50* |
| UHURU | | | | 165 | 128 |
| LUNA | | 204 | 205 | 141 | |
| WARIBE | | | | 157 | |

*a different male associated with Laloyo and mated

Note: where no data is shown in any column, it indicates there was less than 100 hours of association in the month indicating no part of a consort relationship

C.2.3 Copulation and Conception

The dates of conception for 26 births where gestation periods are known or can be estimated occurred 7 times in, a month of low rainfall (december, January and February) 11 times in months of high rainfall (april, august and september) and 8 times in months of moderate rainfall (march, may, october and november). The data shows it is unlikely that rainfall has had an effect on the time of conception.

Very little detailed information has been published about the copulation of white rhinos (*Ceratotherium simum*) in the wild. Between September 2010 and April 2021, they observed 81 timed and 20 untimed copulations by the two main breeding males (Taleo and Moja), two newly breeding males (Augustu and Hassani) and seven breeding females (Nandi, Bella, Kori, Donna, Malaika, Laloyo, Uhuru), and two pregnant sub-adult females (Waribe and Luna).

Table C.2.3.1 shows a summary of the total of 101 timed and untimed copulations. Moja was recorded copulating 53 times, Taleo 34 times, Augustu 19 times and Hassani just once. Multiple same day copulations occurred on 30 out of 82 times – on one occasion four times in a day, on three occasions three times a day and twenty occasions twice a day. The table also illustrates the choice of mate with only two females copulating with an exclusive male, six with two different males and one with three of the males. During the same calving period, five of the females copulated with two different males and two females with three different males.

Table C.2.3.2 shows a summary of the duration of the copulations in minutes for each breeding male. The mean duration of a copulation of the five breeding males was 17 minutes. Based on a 16-month gestation period, the duration of the copulations that lead to conception is summarised in Table C.2.3.3. Of the nineteen conceptions, one was the result of three, same-day repeated copulations, seven of two repeated copulations and eleven of a single copulation.

Table C.2.3.4 shows the number of months when a female was first mated after the birth of their new calf and the identity of the male responsible. Of the three older females, the months between new calf birth and mating was shortened with increasing age for Nandi and Kori, while it remained consistent for Bella. Of the 19 records, Moja was the first-choice mate 9 times, Taleo 6 times, with Augustu four times.

The age at which a non-breeding female allowed a first mating is shown in table C.2.3.5 with the average of 3 years and 1 month ($n = 6$). The age at which non-breeding males had their first mating was 17 years and 2 months for Hassani at its only time of mating, while Augustu was 8 years and 7 months old at first mating. Hassani copulated for only 7 minutes while Augustu copulated for 20 minutes. The two older males, Taleo and Moja, had mated before records were started.

A total of 71% of copulations occurred during daytime and 29% during nighttime as shown in table C.2.3.6. On 14 occasions, where copulations occurred more than once on the same day, there was an average of 4 hours between each (range 1–9 hours).

Overview

The data in this study represent the most comprehensive analysis of copulation in wild white rhinos. The experience of Ziwa rhinos shows that copulations are more likely in daylight hours, last for around 10 to 25 minutes and may be repeated on the same day with an average four-hour interval. Repeat copulations may often be necessary for conception. Females may mate with more than one male within the same calving period.

Table C.2.3.1. Summary of 83 timed copulations and 18 copulations not timed of wild white rhinos at ZRS

| Female | No. of Copulations in one Day | Length of each Copulation (mins) | Male |
|---------|-------------------------------|----------------------------------|------------------------|
| Nandi | 4 on one occasion | 40-21-45-50 | Taleo |
| | 3 on one occasion | 23-14-19 | Taleo |
| | 2 on five occasions | 28-10/NT-NT/NT-NT/24-18/25-15 | Taleo / Moja |
| | 1 on eight occasions | 15-23-21-17-20-NT-29-10 | Moja/Augustu |
| | | | |
| Bella | 3 on one occasion | NT-19-12 | Moja |
| | 2 on three occasions | 6-30/NT-NT/35-22 | Taleo |
| | 1 on six occasions | 20-31-NT-NT-NT-35 | Moja / Taleo |
| | | | |
| Kori | 2 on two occasions | 18-8/NT-NT | Moja / Taleo |
| | 1 on seven occasions | 22-NT-NT-NT-NT-NT-26 | Moja / Taleo |
| | | | |
| Donna | 2 on two occasions | 13-13/12-18 | Taleo |
| | 1 on two occasions | 21-21 | Taleo |
| | | | |
| Malaika | 1 on eight occasions | 18-23-14-5-22-NT-5-21 | Taleo / Moja / Augustu |
| | | | |
| Laloyo | 3 on one occasion | 5-7-15 | Moja |
| | 2 on one occasion | 5-13 | Moja |
| | 1 on eight occasions | 13-13-11-18-18-20-NT-17 | Taleo / Moja |
| | | | |
| Uhuru | 2 on three occasions | 14-16/14-16/19-12 | Augustu |
| | 1 on five occasions | 12-15-15-13-23 | Moja / Augustu |
| | | | |
| Waribe | 2 on two occasions | 9-12/15-14 | Moja / Augustu |
| | 1 on one occasion | 7 | Hassani |
| | | | |
| Luna | 2 on two occasion | 17-12/16-18 | Moja |
| | 1 on four occasions | 7-14-12-10 | Moja |

Table C.2.3.2. Average Copulation length for each breeding male (minutes)

| Male | Average Copulation time | n | range |
|---------|-------------------------|----|-------|
| Taleo | 23 minutes* | 26 | 6-50* |
| Moja | 14 minutes | 39 | 5-31 |
| Augustu | 17 minutes | 17 | 5-35 |
| Hassani | 7 minutes | 1 | |
| MEAN | 17 minutes | 83 | 5-50 |

*in the case of Taleo, the four long copulations on one day are extreme in comparison to the other data and could be due to the observers recording more of the mating process than the copulation phase. If these data are removed (see table 1) the average time of copulation for Taleo is reduced from 23 to 20 minutes, range 4-35 (n=22).

Table C.2.3.3. Length of time in minutes taken for copulations resulting in conception

| Female | Length of believed conception copulation | Male |
|---------|--|---------|
| Nandi | 28-10/21 | Taleo |
| Nandi | 21/20 | Moja |
| Bella | NT-19-12/31 | Moja |
| Bella | 35 | Augustu |
| Kori | 18-8 | Moja |
| Kori | 22/26 | Taleo |
| Donna | 13-13/12-18 | Taleo |
| Malaika | 22 | Augustu |
| Malaika | 21 | Moja |
| Laloyo | 18/17 | Moja |
| Luna | 17-12 | Moja |
| Luna | 16-18 | Augustu |
| Uhuru | 19-12 | Augustu |

Table C.2.3.4. Number of days after birth of new calf when the first mating takes place

| Female | First mating after birth of new calf (days) |
|---------|---|
| Nandi | 187-234-87-79-74 |
| Bella | 300-233-279-244 |
| Kori | 203-218-189-56-197 |
| Donna | 532-576 |
| Malaika | 374-156 |
| Laloyo | 216 |
| Uhuru | 24 |
| Luna | 611 |
| MEAN | 241 (n=21) |

Table C.2.3.5. Age of female at first mating

| Female | Age at first mating |
|------------|---------------------|
| Donna | 2y 11m |
| Malaika | 3y 6m |
| Laloyo | 2y 11m |
| Uhuru | 3y 1m |
| Waribe | 3y 6m |
| Luna | 2y 8m |
| MEAN (n=6) | 3y 1m |

The very young age of the females at first mating with their subsequent young age at first birth has resulted in an extended period between the first birth and first mating after the birth (see Donna and Luna).

Bella has always shown a longer inter-calving interval than other females. The data shows she delays first mating after the birth of her calves probably to ensure she is in the best condition before calving again.

Table C.2.3.6. Number of copulations by Day (7am to 6.59pm) and by night (7pm to 6.59am) for each female rhino.

| Female | No. Day | No. Night | TOTAL |
|-----------|---------|-----------|-------|
| Nandi | 11 | 4 | 15 |
| Bella | 8 | 3 | 11 |
| Kori | 7 | 0 | 7 |
| Donna | 3 | 0 | 3 |
| Malaika | 2 | 4 | 6 |
| Laloyo | 6 | 5 | 11 |
| Uhuru | 5 | 1 | 6 |
| Waribe | 4 | 2 | 6 |
| Luna | 2 | 1 | 3 |
| ALL (n=9) | 48 | 20 | 68 |

C.2.4 Gestation Period

The gestation periods that are known or can be estimated are shown in table C.2.4.1.

Table C.2.4.1. Known and estimated gestation periods for 12 births at Ziwa Rhino Sanctuary

| | | | | | |
|---------|------|-------|------|-----|-----|
| NANDI | 473 | 500 | 500 | 495 | 483 |
| BELLA | 489 | 507 | 488 | 508 | 491 |
| KORI | 482 | 495* | 490* | 494 | 495 |
| DONNA | 506* | 494* | | | |
| MALAIKA | 491 | 494** | 500 | | |
| LALOYO | 498 | 480 | | | |
| UHURU | 476 | 482 | | | |
| LUNA | 495 | | | | |
| WARIBE | 503 | | | | |

gestation period based on last observed mating and known birth date except where * which are estimates based on probable mating when the female was Out Of View or ** where there is evidence that there could be missing information as the male was present for a longer period.

changes = Kori 495 was 525 days, 490 was 585 days; Donna 506 was 562 days, 494 was 555

Malaika 494 was 464 days

Table shows the estimated gestation periods associated with 26 births. Estimates have been made based on observed matings and actual birth dates. The data shows that the range of gestation periods was between 473 and 508 days with an average 493 days. The standard deviation for the periods is 9 giving a range 484-502. This means that there were 8 periods outside the range with 5 lower and 3 higher.

When compared to the range found in zoos of 490-510, eight were lower but none higher.

C.2.5 Birth

The main sign that a female will shortly give birth is when it chases away its current calf. The time from when the former calf is chased off and the birth of the new calf has been recorded on 9 occasions with an average of 6 hours 8 minutes, (range 2 hours 17 minutes to 16 hours 59 minutes).

The action of chasing can vary from highly aggressive to passive and a female may not even bother to chase the calf off at all.

The month of birth and type of season (dry, wet or transitional) is shown in table C.2.5.1

Table C.2.5.1 The number of ZRS births per month and the type of season

| Month | Births | Season | Month | Births | Season |
|-------|--------|--------|-------|--------|--------|
| Jan | 5 | DRY | Jul | 1 | WET |
| Feb | 2 | DRY | Aug | 4 | WET |
| Mar | 2 | TRNS | Sep | 1 | WET |
| Apr | 2 | WET | Oct | 2 | WET |
| May | 0 | WET | Nov | 0 | WET |
| Jun | 7 | TRNS | Dec | 3 | DRY |

This shows there was no seasonal preference with 7 births in the dry and wet seasons and 9 in the transitional months.

Of 25 births having been time recorded at Ziwa, 12 were during the daytime (7am to 7pm) and 13 during the night-time (7pm to 7am).

C.2.6 Suckling

Some aspects of suckling have been recorded from 01/01/2017 to 31/5/2019 for 8 females with new calves. During the period some 4178 suckling observations were made.

The average number of sucklings per day for each of the 8 females was 3 (range 2 to 4) with the range in number of sucklings per day across all records was 1 to 12.

The 4178 records of suckling could be apportioned by the age of the calf, in months:

0-6m 35% 7-12m 22% 13-18m 23% 19-24m 14% 25+m 5%

The reduction in the amount of suckling as the calf gets older would be expected as it gradually weans off milk on to eating grass and drinking water.

In summary, females chased off their calf on the same day that they give birth to a new calf. There was no preferred month or season of birth. Suckling can last from the first day until almost prior to when the female has a new calf but normally diminishes in frequency over this period.

C.3. DETAILS OF A WHITE RHINO BIRTH

The data was obtained by close analysis of the video taken of the birth of a calf to the female Kori in January 2014. It is extremely rare to witness the birth of a rhinoceros calf in the wild, let alone video the experience and was a consequence of the 24 hours a day monitoring at ZRS.

The adult female named Kori was expected to have her third calf in January 2014 following a calving interval of 24 months as had been experienced with her previous calf. The monitoring rangers were diligently watching for signs of an impending birth especially the current calf being aggressively chased off.

On 15 January, Kori was resting from the afternoon heat in a small grass area surrounded by open tree vegetation with her calf Laloyo, and two sub-adults – four year old Justus, her first calf and two and a half year old Malaika, the second calf of the female Nandi. Another female, Bella, with its calf Donna, its first calf Augustu now a sub-adult of four years and three month old and the sub-adult Obama, four years and seven months old were also resting only a few metres away. Detailed data was not recorded prior to the birth of the calf.

However the rangers who were monitoring the rhinos noted their observations when, around 3pm, the behaviour of Kori changed from being very calm to very agitated moving around the immediate area, urinating many times and intermittently feeding.

At 4pm Kori made the rhinos that were accompanying her, including her calf Laloyo, move away some 20 metres in a forceful but not aggressive manner. All moved off immediately and without any confrontation. Kori continued to be restless and did not settle for a further hour at which point she returned to an area she had visited twice before during the hour.

The monitoring rangers reported to Head Quarters that Kori might be due to calve. Senior personnel attended with a Sony digital high definition video camera recorder (DVS 01179747911) using Sony MiniDV tape.

Filming was started at 5.08pm with the real time to the second displayed on each frame so was acceptable for analysis.

Table C.3.1 shows the main observations made and the length of time that expired between specified observations. For example, observation 2 - water bag breaks and observation 3 - calf drops, time expired 3 minutes 7 seconds. The total length of time analysed was 37 minutes and 31 seconds.

The birth of the new calf, starting around 5pm, was in broad daylight which was a complete change from six previous births at ZRS (which all occurred during night-time hours). Kori showed no aggression towards Laloyo or its two companion rhinos and all three remained within 20 metres of Kori before and during the birth of the new calf. When Kori had her first calf, Justus, it also left without aggression around 3 hours before her new calf, Laloyo, was born.

Kori burst the water bag by leaning up against a tree for 6 seconds. At 5.13pm the calf dropped and lay still for 58 seconds before its first movement which was to shake its head after which its main actions were to move by wriggling, attempting to stand, standing, walking by staggering, its first suckling and its first true walk.

The first time the calf attempted to stand was 3 minutes and 4 seconds after the birth.

Kori's calf attempted to stand a further fifteen times over a 16 minute and 33 second period. In all the attempts to stand by Kori's calf, it raised the front legs but collapsed as it tried to stand on its rear legs. The first completed standing was with the front legs in the correct position while the rear legs were extended backwards.

During the period that the calf failed to stand, it moved its position by wriggling around on its stomach. It only did so to change the direction it was facing. It did this action seven times.

Table C.3.1. The time between main observations of the birth of a wild white rhino calf at Ziwa Rhino Sanctuary

| time | | Observation activity | From 1 to 2 | from 2 to 3 | from 3 to 4 | from 3 to 5 | from 3 to 6 | From 3 to 7 | from 3 to 8 | From 3 to 9 | from 3 to 10 |
|----------|----|------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|
| 17.09.20 | 1 | Water bag in view | | | | | | | | | |
| | | | | 1m 13s | | | | | | | |
| 17.10.33 | 2 | Water bag breaks | | | | | | | | | |
| | | | | | 3m 7s | | | | | | |
| 17.13.40 | 3 | Calf drops | | | | | | | | | |
| | | | | | | | | | | | |
| 17.14.38 | 4 | First movement | | | 58s | | | | | | |
| | | | | | | | | | | | |
| 17.16.44 | 5 | First attempt to stand | | | | 3m 4s | | | | | |
| | | | | | | | | | | | |
| 17.16.52 | 6 | First wriggle movement | | | | | 3m 13s | | | | |
| | | | | | | | | | | | |
| 17.33.17 | 7 | First time standing | | | | | | 19m 37s | | | |
| | | | | | | | | | | | |
| 17.34.49 | 8 | First time staggering | | | | | | | 21m 09s | | |
| | | | | | | | | | | | |
| 17.48.09 | 9 | First suckle | | | | | | | | 34m 29s | |
| | | | | | | | | | | | |
| 17.51.11 | 10 | First walk | | | | | | | | | 37m 31s |

Laloyo became interested in the new calf, its sister, 2 minutes and 53 seconds after the birth and walked towards it. Kori moved to block its way but then turned aside to let the calf and Laloyo meet. The calf wriggled 90 degrees to face the head of Laloyo and the two smelled each other. After a total of one minute, Kori decided to move Laloyo away from the calf by standing between the two but with Layolo and Justus standing only a few metres away.

Bella's group moved within 10 metres of Kori and calf 4 minutes and 7 seconds after the birth. Kori charged 3 steps at them as a warning and stood, then sat, as a barrier between the group and her calf. A minute later Kori's group joined Bella's group so that there were six rhinos all standing within 5 metres of Kori and the calf. After 1 minute and 36 seconds, Kori became agitated and stood up aggressively making the group disperse.

The new calf was able to stand properly 19 minutes and 50 seconds after its birth. A further 1 minute and 32 seconds later, it made its first attempt to walk but without sufficient leg strength it could only stagger using the body of the mother Kori to help it remain upright. The staggering attempts of the calf were considered to be as efforts to get to the udder to suckle. After the fourth stagger, Kori lay down on her right flank to expose her udder to the calf. However, the calf, while in a good position, did not suckle but remained leaning on the flank, possibly too tired from its 3 minute and 40 second struggle to get to the udder. Kori reacted by standing and moving around to make the teats easy for the calf to access but the calf appeared to have to concentrate on standing.

Kori remained standing for a further 7 minutes and 21 seconds when it lay down for a second time and 16 seconds later the calf attempted to suckle for the first time. It is not clear if the calf successfully suckled and the action lasted less than 30 seconds. This first attempt was 34 minutes and 29 seconds after the birth. The next attempt to suckle appeared to occur 3 minutes and 2 seconds later and again was for only 15 seconds. During this time Kori appeared to be unsettled by the movement of the calf around her.

The first time the calf started to walk normally - without staggering or leaning against the mother – was 37 minutes and 31 seconds after the birth.

Table C.3.2 gives a detailed timeline for the birth of the new calf from when the female showed signs that the birth was imminent up until the calf starts to walk.



Table C.3.2. Detailed timeline for the birth of a new calf to female Kori

| TIMELINE | ACTIVITY |
|----------|---|
| 17.08.00 | Kori shows signs of due to give birth |
| 17.09.20 | Water bag in view while moving slowly around |
| 17.10.21 | Backs up to a tree |
| 17.10.23 | Pushes water bag into tree |
| 17.10.29 | Stops pushing against tree |
| 17.10.33 | Bag breaks and walks away with water leaking, walks five steps, turns, |
| 17.10.43 | stands with some head movement |
| 17.11.30 | Calf starts to appear, Kori sits down and lies slightly on right side, head upright |
| 17.11.55 | Lays head down; now completely on right side |
| 17.12.12 | Slight lift and drop of left rear leg |
| 17.12.17 | Slight lift and drop of left rear leg |
| 17.12.20 | Jerky lift of left leg and drop, three times |
| 17.12.33 | Turns back into sitting position |
| 17.13.02 | Rhino next to Kori stands |
| 17.13.40 | Calf drops out, Kori stands, turns to face calf on ground, rubs face along calf flank |
| 17.14.38 | First calf movement of shaking head |
| 17.15.30 | rubs face along calf flank |
| 17.16.35 | Other rhinos now show interest |
| 17.16.44 | Calf makes first clear attempt to get up |
| 17.16.52 | Calf wriggles around 180 degrees to face Kori's head as SA rhino moves in close |
| 17.17.19 | Calf wriggles 90 degrees to face SA as it is very close and becoming agitated moving head from side to side |
| 17.17.33 | Kori moves to push SA away, keeps face on or near the calfs flank |
| 17.18.08 | Kori sits |
| 17.19.04 | Second attempt to stand |
| 17.19.15 | Third attempt to stand but falls onto side |
| 17.19.33 | Fourth attempt to stand |
| 17.20.37 | Starts to turn using front legs; 10 seconds |
| 17.21.16 | Fifth attempt to stand but falls onto side |
| 17.21.21 | Sixth attempt to stand |
| 17.21.32 | Shakes head |
| 17.21.49 | SA male rhino walks away, Kori stands |
| 17.22.02 | Calf wriggles 180 to face Kori, tries to stand, collapses onto right side |
| 17.23.15 | Kori sits down alongside calf |
| 17.23.47 | Calf tries to stand, collapses onto right side |
| 17.24.05 | Calf puts face between Kori horns |
| 17.24.19 | Calf tries to stand |
| 17.25.07 | Calf tries to stand |
| 17.25.47 | Calf tries to stand, collapses onto left side |
| 17.29.07 | Calf wriggles around 180 to face away from Kori |
| 17.29.30 | Calf wriggles around 180 to face Kori |
| 17.30.00 | Calf tries to stand |
| 17.30.46 | Calf tries to stand |
| 17.30.53 | Calf tries to stand |
| 17.31.07 | Calf tries to stand |

| | |
|----------|--|
| 17.32.03 | Kori stands, turns 180 facing away from calf, moves backwards and rubs head on calf head |
| 17.32.34 | Kori moves to stand with head over the calf seemingly to protect it as a SA comes close which then stops. Kori moves to stand between the calf and other rhinos as they approach |
| 17.33.02 | Calf wriggles 90 to face oncoming rhinos and stands on front legs but collapses onto left side |
| 17.33.12 | Calf tries to stand as SA rhino comes forward |
| 17.33.17 | Calf stands on all four legs for first time but rear legs are extended backwards |
| 17.33.30 | Calf collapses while struggling to remain upright |
| 17.33.36 | Kori sits down |
| 17.33.38 | Calf stands |
| 17.33.47 | Calf collapses |
| 17.33.58 | Calf struggles to feet over 6 seconds |
| 17.34.08 | Calf collapses |
| 17.34.12 | Calf stands, takes one step with back right leg |
| 17.34.30 | Calf collapses but gets straight up, makes one step with left leg |
| 17.34.39 | Calf collapses |
| 17.34.49 | Calf stands and struggles to walk |
| 17.35.08 | Calf stands, staggers 3 steps |
| 17.35.21 | Kori pushes it over as its direction is on her open side so less secure |
| 17.35.25 | Calf stands on near side of Kori and staggers/stands/staggers/leans on mother as it tries to get around her front left leg |
| 17.37.22 | Calf finds strength to stagger round the leg |
| 17.37.38 | Kori lies down on right flank to expose udder |
| 17.39.05 | Calf moved to correct position but does not appear to suckle and just leans against the flank |
| 17.40.32 | Kori stands, moves around for calf to access right teat and keeps moving as it seems to try to make it accessible to calf who just appears to concentrate on standing up and staggering a small distance |
| 17.41.45 | Calf turns to touch faces with Kori and rubs her face and horns |
| 17.43.10 | Calf moves to rear end of Kori |
| 17.44.11 | Kori turns around, calf staggers to the head end again |
| 17.45.00 | Calf moves round to the rear of Kori |
| 17.45.05 | Rhinos come to see calf and Kori charges 4 steps at them keeping the calf sitting behind her |
| 17.45.10 | Kori stands her ground against the other rhinos |
| 17.47.53 | Kori lies down on right side to enable calf to suckle |
| 17.48.09 | Calf suckles (believed to be the first time) with other rhinos looking on |
| 17.49.21 | Calf staggers to head of Kori |
| 17.50.06 | Kori stands and is agitated by the other rhinos as one has gone around the back |
| 17.50.42 | Kori and calf standing head to head |
| 17.51.00 | Calf walks/staggers along side of Kori |
| 17.51.06 | Calf stands to recover |
| 17.51.11 | Calf walking better to udder, possible suckle |
| 17.52.00 | Calf walks but unsteadily around Kori |
| | VIDEO ENDS |

C.4. Early first white rhino calving and consequent foot problem

Donna is the second born calf of the adult female Bella at ZRS. In June 2016, and for the previous 26 months from April 2014, Donna was found in close association with two older male sub-adults Obama and Augustu, the latter being the first calf of Bella, therefore her older brother.

At around 9am, Donna turned on Obama and was restless. From the sub-adult female, 3pm Donna came into labour giving birth at the age of 4 years, 5 months and 20 days, to a male calf, later to be named Ajabu. with Obama and Augustu in close proximity.

C.4.1 Conception

Given a 16-month (487 days) gestation period, as had been recorded on three occasions at Ziwa, Donna would have conceived at 3 years, 1 month and 20 days old being on/around March 1st, 2015.

Monitoring data shows no male attention shown to Donna in February or April but five interactions in March—4, 5, 12, 28, 29. On each occasion, Donna went out of view for several hours during which time mating could have occurred. Only on March 29 was mating recorded but it would be misleading to conclude that conception had not occurred at a previous occasion.

Conception at around 3 years, 1 month and 20 days is considered exceptionally early. The main danger at this age is considered to be physical with the heavy adult male potentially damaging the back and/or hind quarters of the small female on mounting. In the case of the Ziwa rhinos in general, including Donna, the climate and habitat enables rapid and nutritious grass growth such that they reach a size and bulk well in excess of that normal for their age.

C.4.2 Health of Calf—Ajabu foot problem

It took some two to three hours for Donna's calf Ajabu to stand and clearly Donna was concerned as she nipped him on his side to encourage him to get up. Indeed, at one stage, Donna tried to get his ears in her mouth to lift him. Once the calf stood up and started to walk, it became clear that there was a problem with its right hind leg. The foot was not able to lie flat on the ground and the sole pointed upwards from the heel. Despite this, over the next few days, the calf was able to walk further but only ran for a short distance if he got a fright. Ajabu was a big calf, definitely no smaller than any of the other calves born on the sanctuary.

After six days, the footpad clearly showed the villous surface texture normal for new-born rhino and which only forms into normal foot skin with use which was not possible at that time. (Figure 1, 1-8; see colour plates: page vii). Sixteen days after Ajabu's birth locomotion improved. Ajabu was able to make a foot print, with the sole of the foot pressing on the ground, although it was described as 'a bit spiky'. Experienced vets agreed the cause of the problem was a contracted tendon probably due to bad positioning of the calf in the uterus (the most common cause of the problem in horses with their long limbs and more frequent size mismatch between dam and foal is due to uterine malposition).

As the contracture was releasing spontaneously and as the calf was starting to take weight normally while still at such a young age, it was thought likely that the joints and overall conformation of the limb would become normal. Ten weeks after the birth, the foot appeared to be completely normal.

C.4.2.1 Conclusion

White rhino female sexual maturity in the wild could be reached as early as 3 years of age with an age at first calving more likely to be 5 to 5.5 years than between 6 and 7 years as the literature generally suggests. Furthermore, it has been concluded that the most plausible cause of the calf's foot problem was due to the early pregnancy. The size of calf was large for the relatively young mother resulting in a tendon contracture of Ajabu's right hind foot.

SECTION D Building a white rhino social organisation at ZRS

This section presents an analysis of the rhino monitoring data and charts the development of the social organisation of the rhinos at the sanctuary. The analysis is based on the number of twenty-four hours long periods that an individual was either (a) alone or (b) in an association with one or more other individuals. An association was defined as occurring when two or more animals were within 10 metres of each other for more than 24 hours.

With only three founder females, in the early years the opportunity for associations that occur when a former calf is chased away by its mother when due to have a new calf, were few.

Obama, the first calf born on Ziwa, was with his mother, Nandi, up to the time of the new birth. After the calving, Obama, now a 24 month old sub-adult, remained in close association with his mother for nearly 8 days (191 hours).

He then moved away to form an association, lasting 6 months, with the female Kori and her calf Justus, up until the birth of Kori's new calf. At this time there was no alternative to an association with a female and calf pair as there were no other subadults in the population for Obama to associate with.

Augustu, the second calf born on Ziwa, was in association with his mother, Bella, until the birth of her new calf but remained for only one day afterwards while Justus ceased association with his mother, Kori, the day before the birth of the new calf. At the start of 2012, the three new sub-adults joined up in association within a few hours of the birth of Kori's new calf.

Obama, Augustu and Justus, joined together in an association at 31, 26 and 24 months of age respectively. Six months later Justus (by then 30 months old) left the group and rejoined his mother Kori and her new calf Laloyo. Obama and Augustu remained together for a further 5 months, when they joined up with Bella, the mother of Augustu, and Bella's new calf Donna, then 11 months old. At this point, Obama and Augustu were 42 and 37 months old respectively.

During this time, Justus joined either Obama and Augustu, or Bella and her calf Donna, for one month only and then returned to Kori and Laloyo. The following month Nandi chased away Malaika when she had her new calf Uhuru.

Malaika (24 months) joined Justus (41) with Kori and Laloyo. Six months later, Malaika (30 months) left Justus (47) and Laloyo (23) and joined Obama (54) and Augustu (49), who were still with Bella and her calf Donna.

Two months later, Justus and Laloyo left Kori and her new calf Waribe. When Bella had a new calf in April 2014, her former calf Donna (27 months) joined Obama (58), Augustu (53) and Malaika (34). Malaika left the group two months later in June 2014 and returned to Justus and Laloyo.

From the start of the data collection in June 2010, the three males were of adult age and had become solitary, so did not associate with other individuals in the population excepting for a number of days when a female was close to or ready for breeding. Once mating was over or the female refused, the male went away.

By mid-2014, the social organization had developed into three adult males – Taleo (14 years 6 months), Moja (14 years 6 months) and Hassani (13 years); three adult females – Nandi (14 years 11 months), Bella (14 years 6 months) and Kori (14 years 6 months); and two groups of sub-adults - one group consisting of two males and a female, Obama (60 months), Augustu (55 months) and Donna (29 months) –, and the other of one male and two females, Justus (53 months), Malaika (36 months) and Laloyo (29 months).

When Obama was 5 years and 3 months old, he left his group for one month. During this period he was found on his own or with the adult male Hassani, who was 13 years and 3 months old. He then rejoined Augustu and Donna, but thereafter tended to stay a few metres away from them. From around 6 years old Obama started to spend up to half his time alone and the rest of the time with Augustu and Donna.

The other group was disrupted by the death of Justus in April 2015, then 5 years and 3 months old, after a fight with Taleo. Malaika and Laloyo had used the older Justus as protection from the mating interests of the adult males. Within a month, Taleo was showing interest in Malaika, now 47 months old, but he was superseded the next month by Moja, who was often with the two young females over the following months. Although the two had lost their 'protector' they did not choose to join any of the females or the other sub-adult group.

Following the death of Justus, the three adult males, Taleo, Moja and Hassani, were dehorned in June 2015. This measure was taken to give the remaining sub-adult males, Obama and Augustu, and developing females Malaika, Donna and Laloyo, some protection from injury when the adult males were aggressive towards them. It is possible that the dehorning has resulted, or may in the future result in changed patterns of association, compared to those that might have evolved had the measure not been taken.

In September 2015, female Nandi had a new calf and chased away her 27-month old former calf Uhuru. Two hours later, Uhuru joined up with female Kori and her 21-month old calf Waribe, with whom she remained for 6 months.

The three males did not form long term associations. On average, males stayed with adult females for between one to three 24-hour periods in a month. Moja and Hassani formed such temporary associations equally with each of the three females. However, the female Kori allowed the male Taleo to form associations that lasted about twice as long as those he formed with Bella and Nandi. Males only stayed with sub-adult males for, on average, between one and two 24-hour periods per month.

Of the three adult females, Bella and Kori (with their calves) have accepted associations with juvenile and sub-adult individuals while Nandi has preferred to remain alone with her current calf.

Juveniles that had been chased away by their mother prior to the birth of a new calf formed an association within as little as two hours with another group, either a female and calf or a group of sub-adults.

D.1 Long Term Associations

A long-term association was considered to be of a duration of 6 months or longer where two or more rhinos were together for around 90%+ of the time recorded, in calendar months

The longest association was for the sub-adult males Obama and Augustu which lasted for 63 months. They came together when Obama was 2 years 7 months and Augustu 2 years 2 months old and parted, following a serious fight between the two, with Obama 7 years 10 months and Augustu 7 years 5 months old.

During their association they were joined by other individuals for six or more months at a time. When Obama and Augustu first came together, they were joined by another sub-adult male Justus, aged 24 months who stayed for 6 months. Immediately afterwards, the pair joined up with adult female Bella and her calf Donna for the next 15 months until Bella had a new calf and chased Donna, Obama and Augustu away. Donna, now a sub-adult female, remained with the pair for a further 15 months.

The second longest association of 31 months was between the sub-adult females Malaika, aged 2 years 11 months and Laloyo aged 2 years 4 months.

At the outset of the association they were joined by the sub-adult male Justus aged 4 years 4 months who had been in association with adult female Kori with her calf for 16 months during which time 2 years old sub-adult female Malaika joined them for 6 months having been chased away by her mother Nandi. Justus died from fighting injuries after 13 months of starting his association with Malaika and Laloyo.

Another association between two sub-adult females lasted 24 months. Uhuru at 3 years old and Luna at 2 years 2 months stayed together until Uhuru calved. During the period they were joined by sub-adult female Malaika for 8 months concurrently with sub-adult females Laloyo and Waribe who stayed for a total of 16 months.

Prior to Uhuru joining with Luna, at 2 years 3months old, she associated with adult female Kori and calf for 6 months.

Current Social Organisation – end April 2021

| | | | |
|---------------------------|---|-----------------------------------|---------------------------------------|
| Solitary Males | Taleo Moja Hassani Augustu Obama | | |
| Female + calf | Bella and Jabali Luna and Kuc | Laloyo and Rhoda Uhuru and Rae | Malaika and Pipo Waribe and Anywar |
| Female + calf + sub-adult | Kori and Whittaker + Europe | | Donna and Seiji + Ajabu |
| Sub-adults group of 10 | Sonic + Nguzo + Zawadi + Noelle + Madam + Apache + Kageri + Nakitoma + Armijn + Elias | | |

This large sub-adult group was initially formed in April 2020, out of two previous, smaller groups which were each led by female who left their group to have their first calf. The remaining six all male sub-adults then joined together. The group has been gradually added to by calves that were chased off by their mothers who were having a new calf.

As the older sub-adult males move to maturity, it can be expected that they will leave the larger group perhaps in a pair or singly.

In summary, adult males lead a mainly solitary existence. Adult females associate with their calves and chase away the older sibling when a new calf is born but may subsequently allow the older sibling to return and/or associate with juvenile offspring of other females. Juvenile and sub-adult individuals demonstrated the most dynamic patterns of association.



SECTION E Use of Space by the Rhinos at Ziwa Rhino Sanctuary

This section reports on how the ZRS rhinos have utilised the sanctuary area in order to undertake the various activities outlined in Section B. Table E1 shows that the use of sector/blocks is relatively consistent across the years while table E2 indicates that the rhino prefer the mid-south areas L and R excepting in wet periods when some rhinos move to the higher ground in W.

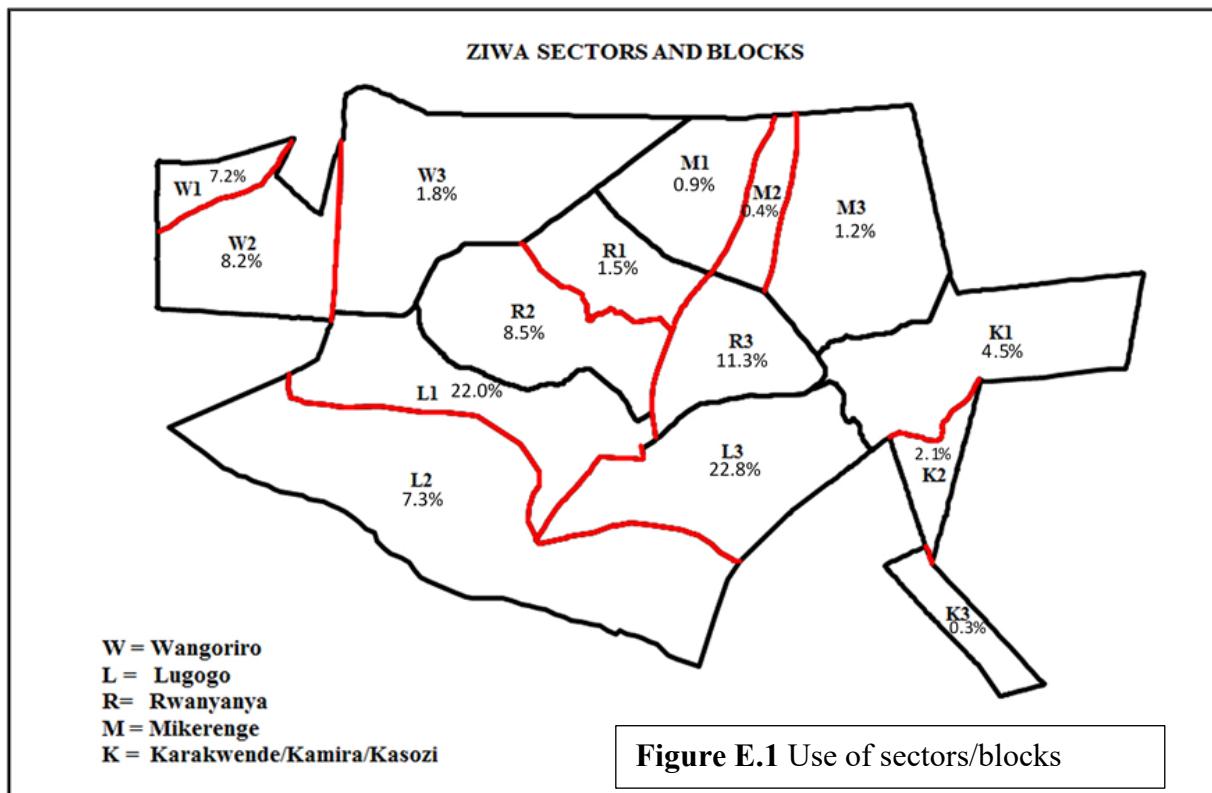
Table E.1. Main percentage use of each sector/block for ten Jun-May years

| YEAR | K | L | M | R | W |
|----------------|-------|-------|------|-------|--------|
| 2019-20 | 3.2% | 52.9% | 3.3% | 24.4% | 16.20% |
| 2018-19 | 5.9% | 58.1% | 3.8% | 21.0% | 11.2% |
| 2017-18 | 4.8% | 68.1% | 2.4% | 10.3% | 14.4% |
| 2016-17 | 8.5% | 56.5% | 2.7% | 11.5% | 20.8% |
| 2015-16 | 10.4% | 35.9% | 2.9% | 28.1% | 22.7% |
| 2014-15 | 4.7% | 56.9% | 0.9% | 18.5% | 18.9% |
| 2013-14 | 5.5% | 40.8% | 3.0% | 36.2% | 14.5% |
| 2012-13 | 4.0% | 44.4% | 2.2% | 27.6% | 21.7% |
| 2011-12 | 1.2% | 45.6% | 2.5% | 22.0% | 28.7% |
| 2010-11 | 1.6% | 47.1% | 6.4% | 29.2% | 15.6% |
| ave | 5.0% | 50.7% | 3.0% | 22.9% | 18.5% |

In the June to May year 2019/2020, the rhinos utilized sectors L and R some 77% with K, M and W only used 23%. Sectors K and W saw less usage than normal as Obama, the main user of sector K moved north to sector M while the older females Nandi, Bella and Kori all spent more time away from W1/W2. Nandi and Kori utilized R2 where a grazing lawn had been created. This lawn was also used by many other rhinos. Bella started to wander widely throughout the sanctuary seemingly to avoid unwanted attention by males.

Table E.2. Average Use of Space by Ziwa rhinos for Jun/May year 2019-2020

| SECTOR/BLOCK | %USE | SECTOR % TOTAL |
|--------------|------|----------------|
| K1 | 2.3 | |
| K2 | 0.0 | 2.3 |
| K3 | 0.0 | |
| L1 | 22.8 | |
| L2 | 10.3 | 52.7 |
| L3 | 19.6 | |
| M1 | 1.7 | |
| M2 | 0.0 | 3.7 |
| M3 | 1.2 | |
| R1 | 1.3 | |
| R2 | 14.0 | 27.6 |
| R3 | 9.0 | |
| W1 | 8.6 | |
| W2 | 6.8 | 16.2 |
| W3 | 0.8 | |



Initially, the male Taleo dominated the whole reserve and mated with the three adult females for the birth of their first two calves. In February 2013, the behaviour of the other adult male Moja changed from being passive to becoming assertive. He also took over breeding rights from Taleo with the mating data showing that he is the father of six of the seven calves born between 2015 and 2017.

There is no clear time when Taleo and Moja established their defended territories but by the start of 2018 it became clear that this had happened. Subsequently, in mid-July that year, the young male Augustu became sexually active and started to attempt mating. Not being as strong as Taleo and Moja, Augustu kept out of their territories moving around his own area waiting for breeding females to stray out of the territories of Moja and Taleo.

From July 2018, when appropriate equipment was issued to monitoring rangers, data has been collected for the locations of the rhinos in daylight hours. This has enabled male territories to be mapped as well as home ranges for females and sub-adults. These are shown in figures E.2.1.to E.2.3. The territories are based on 100% of data less occasional excursion points while the home ranges are based on 66% of all data points collected to represent the areas most favoured by the rhinos.

For the calendar year 2020, the territory of Taleo was 18.1 sq km, of Moja was 10.6 sq km and of Augustu 8.4 sq km. The home range covered by the sub-ordinate males was Hassani 19.8 sq km and Obama 18.3 sq km.

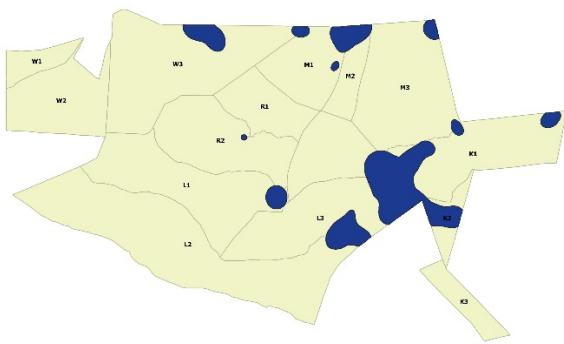
Data collected suggests currently the following Male/Female breeding relationships are:

| | | | | |
|---------|--------|---------|------|-------|
| TALEO | Nandi | Bella* | Kori | Donna |
| 2.2 | 3.0 | 4.7 | 4.1 | 1.2 |
| MOJA | Laloyo | Malaika | | |
| 1.9 | 1.5 | 1.8 | | |
| AUGUSTU | Uhuru | Waribe | Luna | |
| 1.5 | 1.5 | 1.1 | 1.9 | |

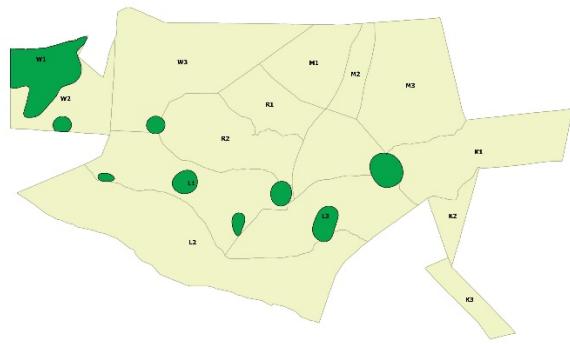
The figure shown below a name is the area, in sq km, represented by 66% of its range. Genetic testing is planned in order to confirm the paternity of all births in ZRS.

Figure E.2.1. Female 66% Home Ranges for year 2020

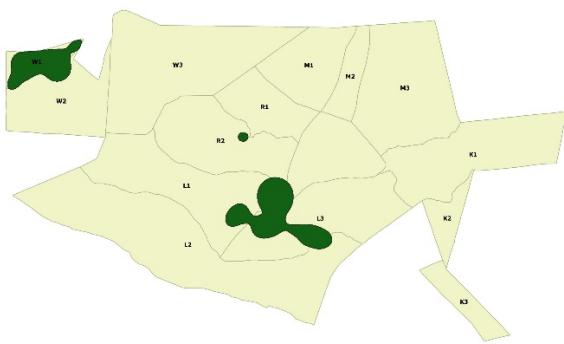
Bella 66% Core Home Range 2020



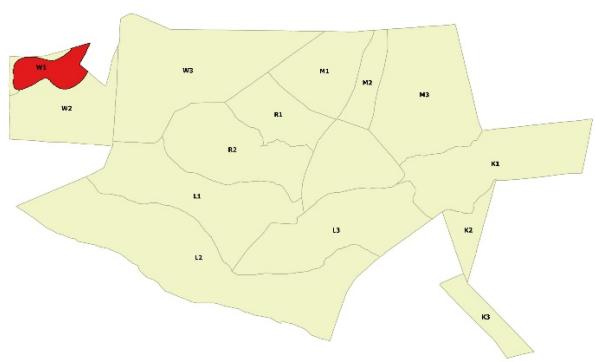
Kori 66% Core Home Range 2020



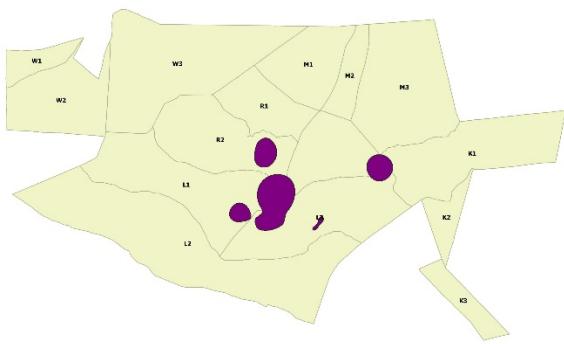
Nandi 66% Core Home Range 2020



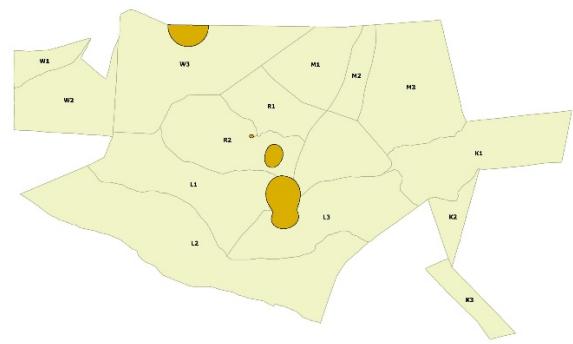
Donna 66% Core Home Range 2020



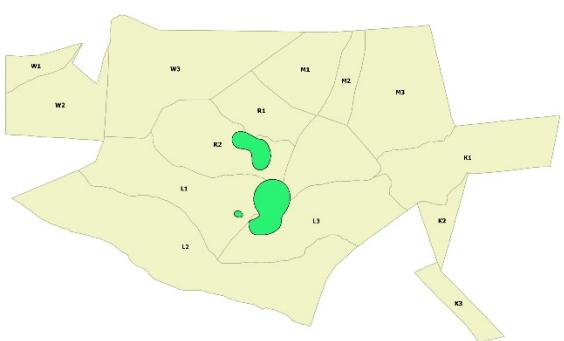
Malaika 66% Core Home Range 2020



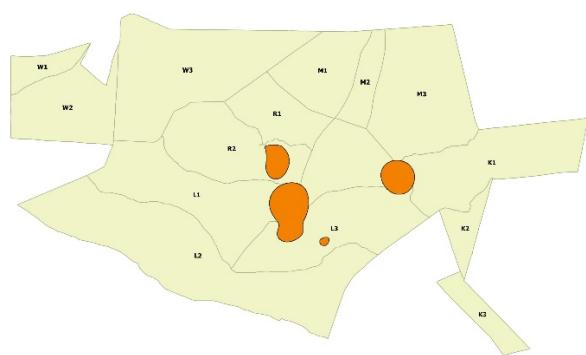
Laloyo 66% Core Home Range 2020



Uhuru 66% Core Home Range 2020



Luna 66% Core Home Range 2020



Waribe 66% Core Home Range 2020

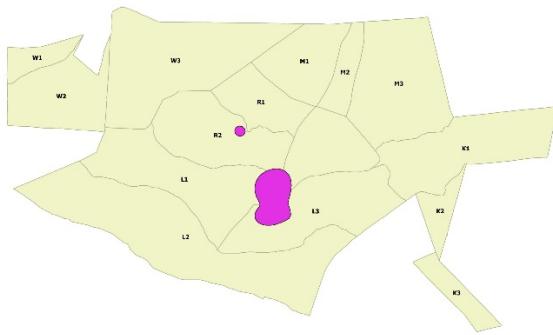
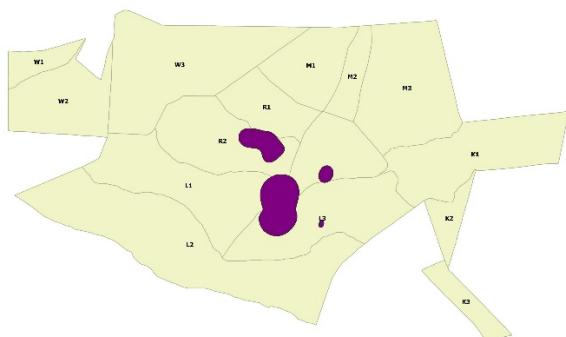
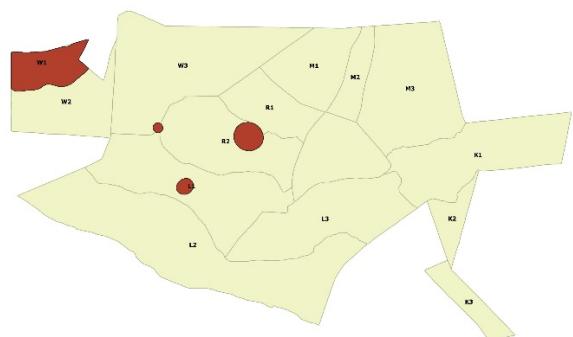


Figure E.2.2. Male and Sub-Adult 66% Territories and Home Ranges for year 2020

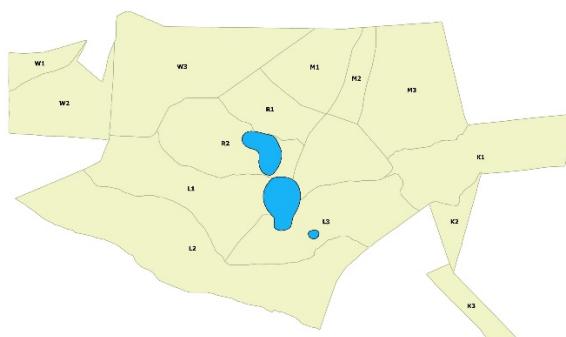
Moja 66% Core Territory 2020



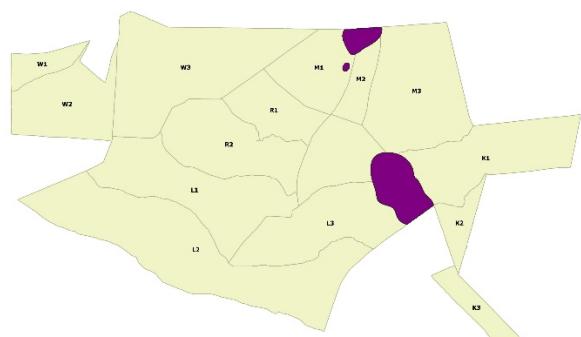
Taleo 66% Core Territory 2020



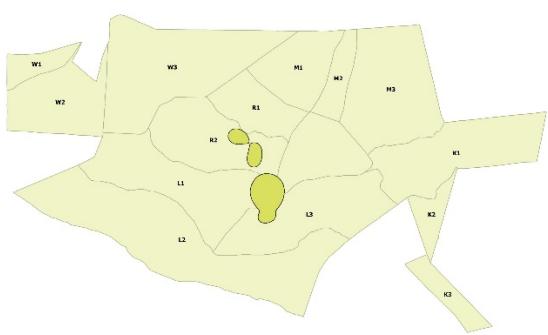
Augustu 66% Core Territory 2020



Hassan 66% Core Home Range 2020



Sub-adult Group 66% Core Home Range 2020



Obama 66% Core Home Range 2020

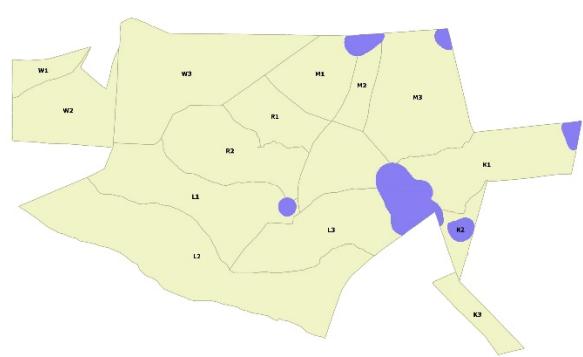
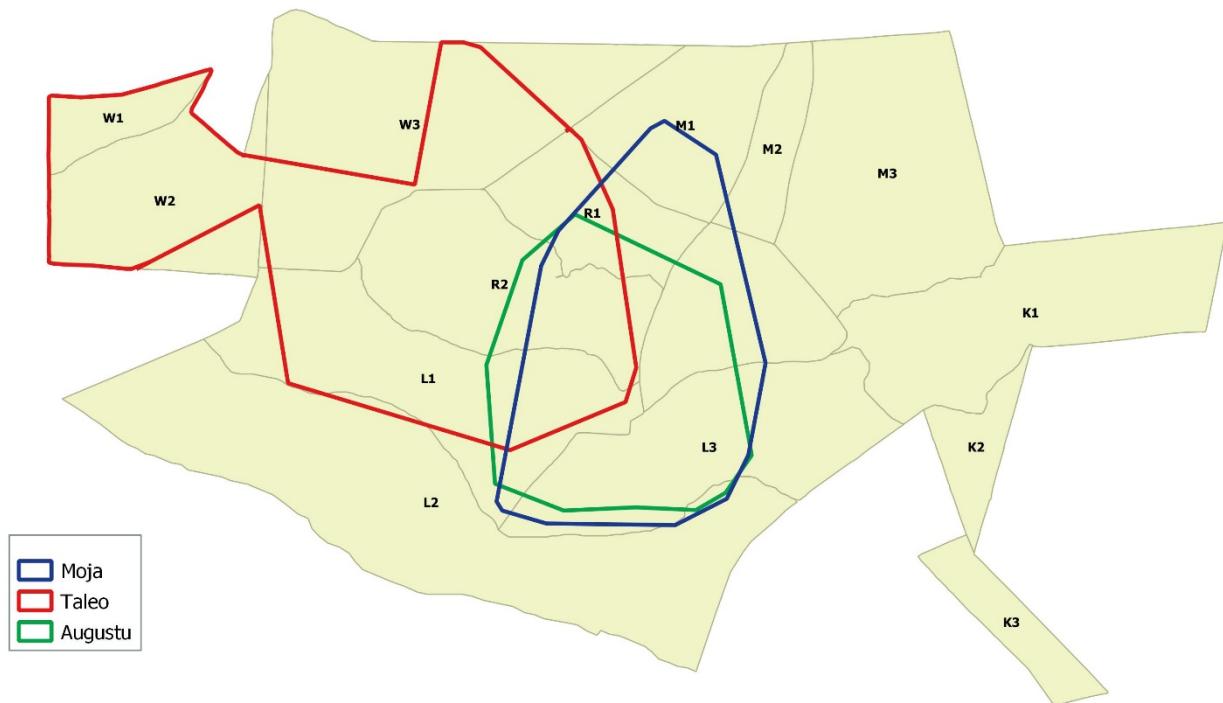


Figure E.2.3. Convex Polygons of the Territories of the Breeding Males at ZRS for year 2020

Breeding Male Territories 2020



In early 2019, Moja, Taleo and Augustu ranges did not overlap - as expected of male territories. Later in 2019 and early 2020, after several fights, Moja and Augustu accepted each other in the same territory often being found within 20 metres of each other even though both were breeding males.

In the latter part of 2020 to date, Taleo has been found in the western part of Moja and Augustu territories in search of females that are no longer ranging in his former area. However, Taleo and Moja/Augustu rarely meet which can be seen in the 66% core area maps above. The 66% core area maps also shows how Hassani and Obama keep out of the way of the breeding males areas.



MOJA



TALEO

Movement across the territories and home range are shown in table E.3. The table illustrates the maximum distance across the 66% ranges and the maximum distance between location points. These represent the extent of the distances travelled in the 12-month data collection period and not on any particular day.

Table E.3. Movement of rhinos within individual territories and home ranges.

| Rhino name | 66% distance, kms | Maximum extent, kms |
|------------|-------------------|---------------------|
| Taleo | 6.6 | 8.2 |
| Moja | 2.6 | 6.3 |
| Augustu | 3.1 | 9.7 |
| Hassani | 4.9 | 13.6 |
| Obama | 7.5 | 8.0 |
| Nandi | 9.1 | 9.5 |
| Bella | 9.6 | 13.7 |
| Kori | 10.1 | 11.2 |
| Donna | 2.0 | 8.6 |
| Malaika | 4.2 | 13.3 |
| Laloyo | 5.8 | 6.5 |
| Uhuru | 2.6 | 6.6 |
| Luna | 3.6 | 8.3 |
| Waribe | 2.5 | 6.0 |
| Group | 2.5 | 6.0 |

It is noticeable that there are some similarities of distances travelled between age/type individuals: Moja/Augustu;; Donna/Uhuru/Luna and the older females Nandi/Bella/Kori. The larger area and distances covered by the older females may be due to them trying to keep away from the unwanted interest of breeding males



AUGUSTU

SECTION F Food Resource and Preference

Before becoming a rhino sanctuary, the area was managed as a cattle farm with the vegetation subjected to severe overgrazing causing large scale bush encroachment and large stands of invasive alien vegetation. This limited the habitat for white rhinos whose principal food source is short grass. In addition, limited access to water for drinking has prevented rhinos from using a significant area of the sanctuary. Both problems reduced the effective rhino carrying capacity.

Initial habitat improvement involving bush burning and cattle grazing was poorly managed with short term gain more important than longer term, sustainable grazing, an outcome of which was several areas being overgrazed.

From 2010, grassland management was carefully planned with controlled bush burning and regulated community cattle grazing the methods employed for habitat improvement for the white rhinos. An initial scientifically based vegetation study was carried out in 2011 by Makerere University student interns which gave a generalized vegetation map for the Sanctuary. This indicated areas where habitat improvement was the most likely to be successful.

Initial success was built upon by also employing contracted manual labour in order to create grazing lawns. Hand clearing areas, particularly of invasive weeds such as Sodom Apple and Lantana camera enabled preferred grass species to flourish and prevent the re-establishment of the unwanted species.

While the result of the habitat improvement work was visually clear, a more detailed assessment of grass quantity and quality was essential for assessing the beneficial effect on Carrying Capacity.

A pilot study to investigate the feeding ecology of the ZRS rhinos and how grazing influences habits was instigated in 2018. The herbaceous species preference by Southern White Rhinos was assessed in rhino feeding habitats and the herbaceous plants and tree composition, and species diversity were compared in feeding and non-feeding habitats.

The results showed that rhinos prefer feeding on grasses to forbs and that they do not feed on trees. The species composition of herbaceous and tree species did not differ markedly between feeding and non-feeding habitats.

The results also showed that the abundance, richness and diversity of herbaceous plants were higher in feeding than non-feeding habitats.

Tree diversity and richness but not abundance were higher in feeding than non-feeding habitats. These results imply that herbaceous plants in feeding habitats showed a positive relationship with abundance richness and diversity.

Following the pilot study, rangers monitoring the rhinos were trained to record daily, on GPS, the most important feeding areas chosen by each family group. From the data gathered, preferred feeding hotspot sites and non-preferred sites were identified.

Each of these sites was sampled for the most and least preferred grass species. The results confirmed that the species identified (tables F1 and F2) in the pilot study were largely the same as those in the hotspots.

Another outcome of these studies was to identify the areas of the Sanctuary not used by the rhinos (figure A). These were sampled to ascertain the potential to be improved as grazing areas although some additional water sources (figure B) would be needed for them to become a preferred habitat for the rhinos.

Table F.1. Species found in the 10 feeding hotspots sampled.

| number | Herbaceous plants eaten | Herbaceous plants not eaten |
|--------|----------------------------|------------------------------|
| 1 | Bermuda grass | Perennial rye |
| 2 | Barn yard grass | Sickle pod |
| 3 | Crab grass | Country mallow |
| 4 | Signal grass | Wandering Jew |
| 5 | Centipede grass | Khaki forb |
| 6 | Lippia weed | Switch grass |
| 7 | Three flowered beggar weed | Sodom apple |
| 8 | Annual rye grass | Prostrate signal |
| 9 | Jungle rice grass | Turkey berry |
| 10 | Asiatic pennywort | Spiny pig weed |
| 11 | Smart weed grass | Mullimbimby couch grass like |
| 12 | Purple nut sedge | St. Augustine grass |
| 13 | Gulf sandmart | Devils horse whip |
| 14 | Slender morning glory weed | Cann plants |
| 15 | Tea senna/mimosa | White head spike sedge |
| 16 | Carpet grass | |
| 17 | Oxalis stricta | |

The table shows of 32 herbaceous plants, 17 were eaten and 15 not.

Table F.2. Species found in the non-feeding habitats sampled.

| Serial Number | Herbaceous plants eaten | Herbaceous plants not eaten |
|---------------|----------------------------|-----------------------------|
| 1 | Bermuda grass | Perennial rye |
| 2 | Tea senna/mimosa | Wandering Jew |
| 3 | Crab grass | Country mallow |
| 4 | Signal grass | Switch grass |
| 5 | Centipede grass | Barn yard grass (mature) |
| 6 | Lippia weed | St Augustine grass |
| 7 | Three flowered beggar weed | White head spike sedge |
| 8 | Annual rye grass | Sickle pod |
| 9 | Jungle rice grass | Devils horse whip |
| 10 | Asiatic pennywort | Red tassel flower |
| 11 | Smart weed grass | Cann species |
| 12 | Silver leaf Desmodium | |
| 14 | Gulf sandmart | |
| 15 | Slender morning glory weed | |
| 16 | Purple nut sedge | |

The table shows there were 27 herbaceous plant species found, of which 16 were preferred species and 11 not.

The map in Figure A below shows that there is a significant area in sector/block W3 which is avoided by the rhinos. It has been determined that this is due to a lack of water sources. A plan has been made to open up the area and supply water through a new borehole for which grant aid was to be applied for.

Grazing Map

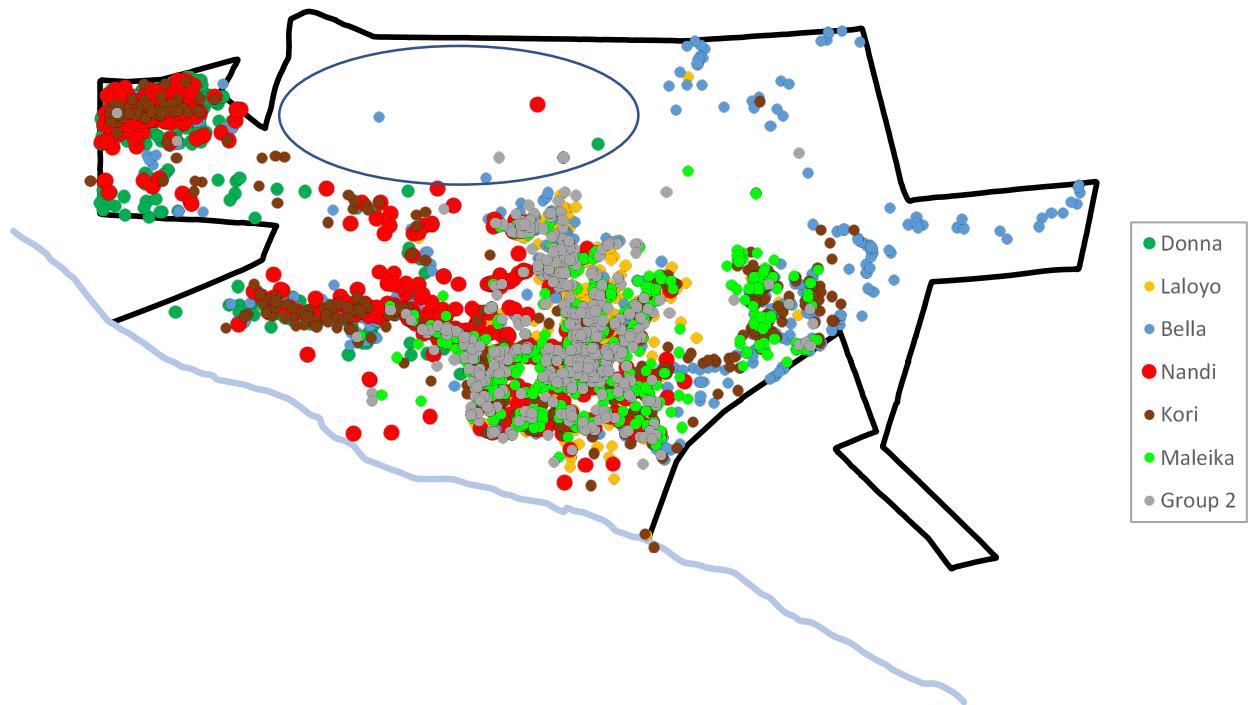


Figure A. Map showing use of space by the white rhinos at Ziwa Rhino Sanctuary.

The ringed area shows minimal/no use and is the area chosen for habitat improvement

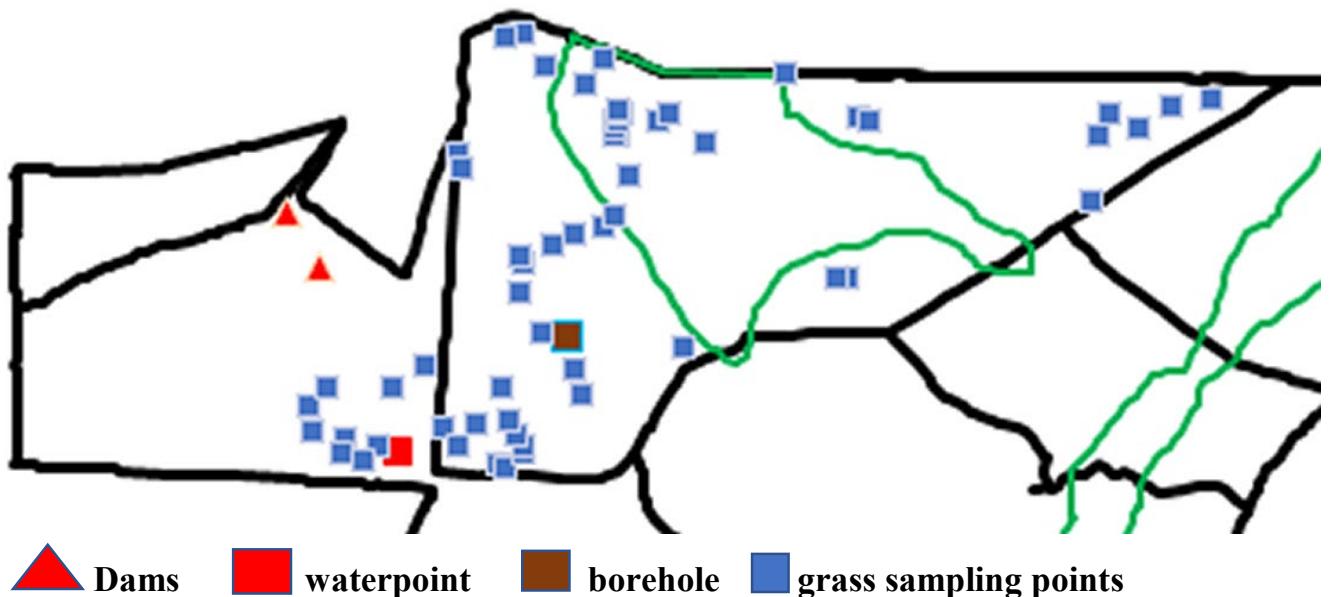


Figure B. Close up map of area for habitat improvement, borehole and waterpoint placement.

Map also shows intensive grass sampling to ensure preferred species are present